THE ECONOMICS OF LITHIC-RESOURCE USE IN SOUTH-CENTRAL FLORIDA

By

ROBERT JAMES AUSTIN

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THIS TITLE IS BOUND IN TWO PARTS.

THIS IS PT. 1.

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KEY TO ABBREVIATIONS

Arch = Archaic
B = Brooksville
BB = Bay Bottom
BBW = Basal-blade Width
BL = Blade Length
C = Caladesi
CHC = Cow House Creek
COB = Cobbles
CV = Coefficient of Variation
DO = Dolomite
FAS = Florida Archaic Stemmed
FB = Fossil Bone
GL = Glass
H or HR = Hillsborough River
KR = Kissimmee Region
L or LS/LP = Lower Suwannee/Lake Panasoffkee
MBW = Mid-blade Width
N = Number
NM = Not Measured
O = Ocala
P = Pinellas
PArch = Post-Archaic
PR = Peace River
SC = Silicified Coral
SD = Standard Deviation
TCP = Turtlecrawl Point
T1 = Type 1
T2 = Type 2
T3 = Type 3
T4 = Type 4
WR = Withlacoochee River
QC = Quarry Cluster
QZ = Quartz
UID = Unidentified
UIDCH = Unidentified Chert
W = Width

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THE ECONOMICS OF LITHIC-RESOURCE USE IN SOUTH-CENTRAL FLORIDA

By

Robert James Austin

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Chairman: Jerald T. Milanich
Major Department: Anthropology

This is a study of the ways in which hunter-gatherers adapt to conditions of limited resources; in this case, the resource of concern is lithic raw materials. The research was designed to examine how prehistoric hunter-gatherers in south-central Florida coped with the costs and risks associated with lithic resource acquisition. It also addresses the effect of limited access to raw materials on organizational strategies, and more specifically, the use of curated versus expedient technologies among residentially mobile foragers and sedentary collectors.

Economic concepts (supply and demand, marginal value, optimization) are used as the theoretical basis for the development of testable hypotheses related to these questions. Lithic artifacts from Archaic and post-Archaic contexts within the Kissimmee Region of south-central Florida form the primary data set for this research. Comparative data were obtained from the analysis of contemporaneous assemblages in the Peace River drainage, southwest Florida coast, and the Tampa Bay region of west-central Florida. Analysis focuses on assemblage structure and composition rather than on functional or technological analyses of individual artifacts. Analysis of waste-flake assemblages derived from the replication of a variety of tool and core forms is included in the study to provide a basis for making valid inferences regarding the technological origins of archaeological debitage assemblages.

The results indicate that the organizational strategies employed by Archaic and post-Archaic populations within the study area were influenced to a large degree by the availability and abundance of lithic raw materials regardless of differences in settlement mobility. That is, when compared with assemblage data from sites located in chert-rich areas, Archaic and post-Archaic groups inhabiting the study area practiced cost-reduction strategies to a greater degree than did their contemporaries farther north. However, intraregional variation existed in the specific cost- and risk-reduction strategies that were employed. These strategies were influenced by several interdependent factors, including settlement mobility and procurement strategies, as well as access to alternative raw materials.

CHAPTER 1
INTRODUCTION

This dissertation is a study of the ways in which hunter-gatherers adapt to conditions of limited resources; in this case, the resource of concern is lithic raw materials. More specifically, my goal is to examine how prehistoric hunter-gatherers in south-central Florida organized their technological systems to cope with the problem of raw-material scarcity.

Lithic studies in Florida have traditionally focused on questions of chronology, technology, site function, and intrasite spatial patterning (e.g., Austin 1983; Austin and Ste. Claire 1982; Ballo 1985; Bullen 1975; Chance 1981, 1983a; Chance and Misner 1984; Daniel and Wisenbaker 1987; Estabrook and Newman 1984; Hemmings and Kohler 1974; Purdy 1981a, 1981b; Purdy and Beach 1980; Ste. Claire 1996). Although these studies have provided valuable information, they have been conducted for the most part as if technology functioned separately from the rest of the cultural system. As a consequence, they have contributed little to an understanding of the dynamics and organizational variability in hunter-gather adaptations that are observable archaeologically in Florida (Prentiss and Romanski 1986). In this study, I attempt to rectify this situation by focusing explicitly on technological organization as an adaptive response to environmental structure.

As defined by Nelson (1991:57), technological organization refers to a set of "strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance." Therefore, when I speak of technological organization I am referring to the strategies that are developed by human beings in response to the necessities of everyday life. The goal of this research is to understand the factors that influenced the decisions to choose particular sets of organizational strategies.

Several factors have been suggested as potentially influencing the organizational character of prehistoric lithic industries. Mobility strategies, time stress, functional efficiency, and access to raw materials are but a few of the more commonly cited. Of these, mobility strategies and access to raw-materials have engendered the greatest interest and debate (e.g., Andrefsky 1994a, 1994b; Bamforth 1986; Binford 1979, 1980; Binford and Stone 1985; Daniel 1996; Gould 1980; Odell 1996; Parry and Kelly 1987; Thacker 1996). South Florida's interior is one of the few areas in the state where prehistoric native peoples did not have direct access to durable raw materials to manufacture tools, potentially limiting their ability to exploit biotic resources. The archaeological evidence, limited as it is, suggests that the region was inhabited by highly mobile hunter-gatherers during the preceramic Archaic period and by more sedentary populations during the post-Archaic. Thus, I believed the region had the potential to serve as a test case for evaluating the role that access to raw materials had on the organizational strategies of both mobile and sedentary hunter-gatherers.

The specific research questions that are addressed by this study can be stated simply:

1) What were the means (procurement strategies) by which siliceous lithic materials were obtained from their source locations and moved into south-central Florida?

2) What were the various strategies adopted by prehistoric native peoples to cope with the costs and risks associated with procuring these resources from distant locations, and did these change through time?

To address these questions, I have structured my analyses to move from a lower-order perspective, in other words, that which is concerned with what is observed archaeologically in the material record, to a higher-order perspective that examines the relationship between environmental structure and organizational strategies. The lower-order perspective of inferring specific behaviors based on observation of the archaeological record is strengthened through the use of experimentally derived data on lithic waste-flake assemblages. Experiments were conducted that were designed to replicate debitage assemblages resulting from different lithic-reduction strategies: patterned-tool (i.e., bifaces, unifaces) and core reduction (large and small). Analysis of the experimental assemblages focused on refining existing techniques for use with archaeological assemblages. The techniques include the Sullivan-Rozen flake typology (Sullivan and Rozen 1985; Rozen 1984) and the flake-size distribution analysis pioneered by Patterson (1981, 1982, 1990; Patterson and Sollberger 1978). Analyses of experimentally derived waste-flake assemblages indicates that the two techniques can be used successfully to distinguish between patterned-tool and core-reduction strategies. The use of these techniques is refined through the application of statistical procedures for distinguishing between the two major reduction strategies. Discriminant-function analysis is used with the Sullivan-Rozen typology while regression analysis and statistical comparison of regression slopes are used to distinguish between flake-size distributions resulting from different reduction strategies.

Moving up the hierarchy of inference, specific hypotheses and test implications are developed regarding the types of problem-solving strategies that prehistoric hunter-gatherers may have practiced in the study area given the condition of limited access to lithic resources. These hypotheses are grounded in microeconomic theory which views scarcity as a central element of economic decision-making (Glahe and Lee 1989:3-5). Economics is the study of how people choose to allocate limited resources that may have alternative uses to achieve specific goals or acquire desired goods or services. Microeconomics focuses on individual decision makers and how they attempt to solve this problem most efficiently. A basic assumption of microeconomics, and of this study, is that the principles of economic decision-making, as defined above, are applicable to all forms of human behavior regardless of cultural context. Every decision that people make involves a cost -- in time, in labor, in goods or services. Moreover, a decision to allocate resources to achieve one goal necessarily requires that resources be diverted from achieving some other desirable goal. Thus, every decision has a direct cost and an opportunity cost, and both must be considered before an intelligent economic decision can be made.

Much of the data used in this research were derived from sites in the Kissimmee region of south-central Florida (Figure 1) with comparative data coming from sites in the Peace River valley, the southwest Florida coast, and the Tampa Bay region. A total of 5256 artifacts from 39 sites was analyzed. Because much of the study area has experienced little in the way of systematic archaeological excavation, the artifacts analyzed for this research came from a variety of collections. Some were derived from test excavations conducted specifically for this study. Many came from test excavations and surveys conducted as part of cultural resource management (CRM) projects. Still other artifacts came from museum collections or private collections. The temporal range of the sites spans the early Archaic period (ca. 9500 B.P.) through the early historic period (ca. 200 B.P.), with most sites, or components of sites, dating to the middle Archaic through late prehistoric periods (ca. 6-7000 B.P. through 400 B.P.).

The basic limitation of this research is the small sizes of the lithic artifact assemblages at sites in the region, particularly those dating to the post-Archaic period. This is partly due to the geological character of the region; that is, the absence of exploitable chert outcrops. The problem is made even more acute, however, by the limited archaeological work that has been conducted in the region, consisting primarily of surveys and test excavations. In anticipation of potential criticism I offer the following quote by Steve Hale regarding the problem of inadequate samples:

> The archaeological record, and our samples, are always incomplete. Rather than avoid analyzing samples that are less than ideal, I prefer to minimize the biases, and make use of imperfect samples that are, in some cases, perhaps the only samples we will ever have [Hale 1995:284].

Thus, rather than ignore or discount the value of the lithic data that do exist, I have chosen to forge ahead in the firm belief that analysis of even small and incomplete samples can offer insights into prehistoric human behavior if it is structured within a theoretical context.

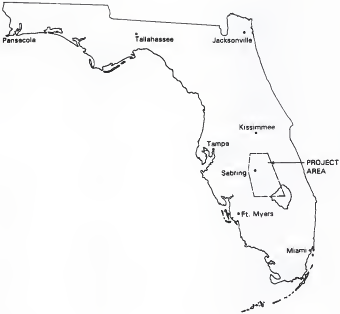


Figure 1. Map of the study area in relation to Florida.

This dissertation is organized as follows. In Chapter 2 I discuss in depth the theoretical framework that guides this study This framework is explicitly materialist and evolutionary. Economic and ecological concepts are introduced and are followed by a discussion of their application to the study of lithic economies. Extended treatments of the environment and geology of the study area are presented in Chapters 3 and 4 to provide an ecological context for the study. A basic assumption that underlies the temporal analysis is that prehistoric people during the preceramic Archaic period practiced a more mobile settlement strategy than did later, post-Archaic groups. This is based, in part, on archaeological evidence, but the nature of the paleoenvironment as it has been reconstructed from palynological, sedimentological, geological, and faunal data also is crucial to this assumption. A separate chapter (4) on geology and chert resources provides the reader with a background on regional geology which is necessary to understand the formation and geographic distribution of chert in Florida.

Chapter 5 provides an overview of the prehistory of the study area. This lays the foundation for much of the assumptions regarding differential mobility strategies and restricted territories that underlie the economic analysis that follows. Chapter 6 outlines a series of hypotheses that have been developed to address the questions posed at the beginning of this chapter. Test implications derived from these hypotheses are specified as are the data necessary to confirm or disconfirm the hypotheses. Chapter 7 describes the methods used in the data collection and analysis of archaeological collections, as well as the methods employed during the experimental replications. The chapter also includes an extended discussion on the method used to identify chert provenience which was a critical aspect of this research.

Research results are presented in Chapters 9-12. Chapter 9 focuses on strategies for coping with procurement risk in a chert-poor area. Procurement strategies (direct versus indirect) are identified as are auxiliary risk-abatement strategies such as resource diversification, scavenging, and storage. Chapter 10 addresses the costs associated with procurement and how these were minimized. Specific labor-reduction strategies that are addressed include minimization of transport costs, minimization of production costs, economizing, and reduction of demand. In Chapter 11 I examine the use of curated versus expedient technologies in the study area. The results of this analysis lead directly to an examination of time-minimizing and resource-maximizing strategies.

The final chapter, Chapter 12, summarizes the results and conclusions presented in the previous three chapters. I also examine the implications of the research results for understanding the evolution of social complexity in south Florida, and more specifically the role that exchange systems may have played in the emergence of social inequalities.

I do not believe that the conclusions presented in this dissertation necessarily represent the "truth" about the segment of prehistoric behavior I have chosen to study. I accept the possibility, even the inevitability, that my conclusions will be modified or discarded entirely with future research. My hope is that this research, however imperfect, will contribute in its way to the process of learning about the past and will stimulate others to continue in this quest.

CHAPTER 2
THEORETICAL FRAMEWORK

The theoretical perspective that guides this study is ecological, materialist, and evolutionary. It takes as given the fact that human beings are biological organisms who exist as part of an ecological system (Odum 1971:8). Like other biological organisms, humans must adapt to the constraints and opportunities afforded them by their external environment. Within this framework, the hunting and gathering lifestyle is viewed as an adaptive response to variation in environmental structure. This structure is composed of a set of interrelated geological, biological, and climatological features with structural variation occurring at varying scales of space and time. Human adaptive responses to structural variation may include differential residential mobility, seasonal scheduling of subsistence activities, the establishment of intra and interregional alliances, the development of exchange systems, complexification of social structure, or the elaboration of ritual.

Yet another way in which human beings respond to variation in the environment is through technology. This study adopts the materialist paradigm that views technology as part of the economic infrastructure on which the structural components of society and ideology rest (Harris 1979:55-56). At the same time, it acknowledges that the relationship between structure, infrastructure, and environment is complex and multidimensional. No single research strategy, and certainly no single study, can hope to explore such complexity in its entirety. Instead, I have chosen to focus on a single aspect of this complex relationship, access to raw materials, and examine how this influenced the organizational structure of one element of prehistoric hunter-gatherer economics, technology.

This study also attempts to understand the selective factors that shaped the organizational structure of technology in a particular geographic region through time. Thus, it will be an evolutionary study in the sense that evolution is viewed as a process by which changes in the frequency distribution of behavioral traits can occur over time as a result of selection acting on existing behavioral variation. The stimulus for selection is often change in an organism's external environment, which includes both the physical and social environments. The study concentrates on the selection process rather than causal processes as the two concepts are analytically distinct. Following Hannon and Freeman (1989), causal analysis focuses on whether one phenomenon or set of phenomena affects the likelihood that a second phenomenon or set of phenomena will occur. Selection analysis focuses on whether the rise to prevalence of a specific phenomenon, for example, a certain organizational configuration, is governed by a specified set of changes in the social or natural environment. The question in selection analysis is whether environmental conditions control the distribution of a phenomenon at different points in time (Hannon and Freeman 1989:16). The cause or origin of the phenomenon is not at issue, and is, in fact, the result of a separate process, that which results in the variation on which selection acts. The rise or prevalence of organizational configurations (i.e., adaptations) is the result of the selection process and, therefore, it is the selection process that governs the dynamics of organizational change (cf. Harris 1979:59-62)

To understand why a certain form of technological organization was selected for requires going beyond a mere demonstration of a relationship between environmental conditions and organizational configuration. It requires an understanding of the economic logic that underlies selection. Microeconomic models of human decision-making provide a methodology for studying the process by which humans make choices in the economic sphere. More importantly, it provides a means of evaluating the adaptive value of these choices, for if these choices are adaptive given a unified set of environmental (natural and social) conditions, then they should be selected for.

In anthropology, the principles and methods of microeconomics have most often been applied to studies of subsistence economies (e.g., Bettinger and Baumhoff 1982, 1983; Earle and Christianson 1980; Gremillion 1996, Keegan 1986; Keegan and Butler 1987), and have contributed to the development of optimal-foraging theory and its application to the study of living bunter-gatherers (e g., Hawkes 1993; Hawkes et al. 1985; Hill 1988; Hill et al. 1985, 1987; Hurtado et al. 1985; O'Connell and Hawkes 1981; Winterhalder 1986; see Smith and Winterhalder 1992a and Winterhalder and Smith 1981 for other applications). While efforts to extend the principles of microeconomics to prehistoric lithic studies are a relatively recent phenomenon (e.g., Bamforth 1986; Bouseman 1993; Boydston 1989; Jeske 1989; Kuhn 1994; Morrow 1996; Torrence 1983, 1989a), sucb an application seems to be a potentially fruitful area of research. Stone was the principal durable raw material in many prehistoric technologies in Florida, and stone tools were used directly in the procurement of many subsistence resources, as well as to manufacture other tools made of wood, bone, and antler. The procurement and use of lithic materials were, therefore, important components of the economic adaptations of prehistoric bunter-gatherers.

Pattern, Scale, and Culture Change

Before examining the various elements of this study's theoretical framework in more detail, it is worth discussing the concept of scale, how it affects observations of both patterning and variability in the archaeological record, and the implications of scale for understanding culture change. The concept of scale is perhaps one of the most fundamental issues in anthropology, as it is in science generally (cf. Butzer 1982; Dethlefsen 1992; Gleick 1987; Keegan 1991; Levin 1992; Levins 1966; Marquardt 1992; Schaafsma 1991). As described by Marquardt (1992:107), the concept of scale refers simply to "the amount of space and time under consideration. Out of an infinite multiplicity of scales, individuals comprehend patterns, recognize homogeneity, plan for the future and operate in the present at different scales." Thus, the observation and perception of patterning is dependent on scale, with different patterns emerging as the scales of reference change. The scale at which pattern is observed is the effective scale (Crumley 1979:166).

To this concept of scale, Marquardt has added the concepts of "structure" and "agency" (Marquardt 1992:104-105). Structures may be physical, such as topography, climate, and natural resources, or sociohistorical, which refers to social, political, and economic institutions and the social relations associated with their functioning. Agency refers to the purposeful behavior of human actors. Marquardt borrows the notion of contradiction from Marxist theory to refer to the dynamic tension that comes about when "human activities take place in constantly changing sociohistorical contexts" (Marquardt 1992:105). These concepts are similar to the concepts of structure, event, and conjuncture used by Braudel in his model of historical process (1972 cited in Cobb 1991:170-171), and are merely different ways of conceptualizing scale. In fact, Cobb (1991:174) observes that Braudel's cyclical model of slow-moving, recurrent "structures" and short, rapid oscillations, or "events," recognizes the "overlapping dimensions of variability" (i.e., scales) that characterize the historical process. Braudel's "conjuncture" is the dynamic intersection of structure and event resulting in "new points of equilibrium within the longer lasting structural cycle" (Cobb 1991:171), and is analogous to the process of resolving contradictions through dialectical critique as advocated by Marquardt (1992:109-110).

Individual Variation and Cultural Pattern

Much of the recent post-processual critique of archaeology revolves around the apparent failure of processual archaeologists to derive general laws of culture change (cf. Hodder 1985; Patterson 1990). This is attributed, in part, to the lack of emphasis in the processualist research strategy on the role of the individual as an agent of change (Patterson 1990:194-195). This criticism is simply the most recent manifestation of the long-standing debate between those who view culture as the sum of things done or thought by individuals who are active participants in its formation and transformation, the so-called "normative" view, and those who view culture as a superorganic entity that exists apart from individuals, operating and evolving according to its own set of rules, deterministically shaping and molding individual behavior.

The debate centers around what Paul (1987.80) has referred to as "autonomy of agency." In other words, if culture is an entity in and of itself, and this entity influences the behavior and thoughts of its members, then culture constitutes the autonomous agent that individuals respond to. On the other hand, if culture emerges from and is maintained by the collective actions of its members, then individuals are the autonomous agents and culture is a consequence of their actions. The history of anthropological theory can be viewed as a recurring struggle between these two points of view for disciplinary dominance -- the primacy of the individual and the particularistic versus the primacy of culture as a system and the search for general laws.

Within this context of theoretical debate, the recognition that nature, including human nature, consists of a multiplicity of scales provides insight in terms of understanding and explaining cultural behavior The goal of science is to abstract, from the infinite range of variability that exists in nature, generalities that enable us to make predictions about cause-and-effect relationships and, ultimately, to understand and explain how and why these relationships occur. However, the degree to which pattern and variability are observed, perceived, or analyzed is conditioned by the scales at which we choose to make our observations. Moreover, the mechanisms that result in observed patterns may operate at scales that are different from those at which the patterns are observed (Levin 1992:1943). In a recent article, Edwin Dethlefsen (1992) addressed this analytical contradiction and the implications it has for archaeology. According to Dethlefsen, the difficulty that we encounter in trying to describe or characterize cultural phenomena in abstract general terms is due to the inherent variability of their component parts. "Scholars who wish to transcend specificity quickly find themselves lost in a sea of exceptions" (Dethlefsen 1992:149). Dethlefsen draws on chaos theory and mathematical topology in an attempt to conceptualize complex patterning in culture. The entire range of possible relationships between variables in a system can be conceived of topographically as the sum total of their intersections -- the entire phase space of the system (Gleick 1987:47). Any single point in this phase space represents a state in the system frozen in time. All the information about that state is contained in the intersection of all variables at that point in phase space. As the system changes, that point moves to a new position and as it continues to move it traces a line or trajectory. This trajectory of random, multidimensional points through time become attracted to a bounded region of phase space, the strange attractor. The lines never intersect one another or travel the same path, yet they form a distinctive pattern of continuous looping that is predictable. The computer-generated images resulting from chaos-inspired research (the fractal geometry of Mandelbrot sets) enable the multivariate relationships of a dynamic system to be visualized in a way that does justice to its complexity (Gleick 1987:83-118).

Battleship-shaped curves are an example of a simple way to visualize dynamics in archaeology. However, this graphic method considers only a single variable -- usually style -- measured against a time scale. Multivariate statistics are another way of comparing large numbers of variables. But as Dethlefsen points out, the ability of computers to manipulate large amounts of data and consider the multiple relationships between them all does not compensate for the difficulty human beings have in representing, thinking, talking, or writing about multidimensional reality. Hence, most of our models of change tend to be limited to the study of one or at best a few variables at a time. While Dethlefsen feels this obfuscates the true dynamic relationships between the large numbers of variables that actually constitute the reality of any population, others (e.g., Levins 1966; Keegan 1991; Winterhalder and Smith 1992) accept that the very complexity of real-world phenomena makes it impossible to construct models that encompass both specificity and generality. Even the Mandelbrot sets of chaos theorists distort and misrepresent the process of dynamic change by reducing it to a static state.

Throughout much of his paper, Dethlefsen is clearly grappling with the contradictions of specificity versus generalization, of variation versus pattern.

> Words force us to set aside the notion that every observation lies somewhere in a distribution curve which in turn exists in a universe of intersecting, mutually influential distribution curves. Everything has to do, more or less, with everything else, but one can neither talk about or illustrate everything at once. Still more difficult to visualize is the concept that every curve of distribution, even though it is itself a generalization, represents some particulate statement about some other, greater curve within which it is merely a point or a transect. Every degree of magnification applied to a concept enhances its systemic ambiguity; thus, if we allow our attention to focus altogether on its fine points, we risk losing track of the line that, when seen at a wider angle, those points constitute [Dethlefsen 1992:152].

In other words, if we focus too closely on the particular, we risk missing the forest for the trees. His reference to the Marcel Duchamp painting Nude Descending a Staircase nicely illustrates his point (Dethlefsen 1992:153). If one focuses on trying to isolate any single image within this graphic representation of motion versus time, then one loses site of the real phenomenon that is occurring -- change. For Dethlefsen it is the generality that offers the greatest potential for understanding (Dethlefsen 1992:149), yet the generalization cannot simply be considered as a larger, more complex representation of individual entities; it is an abstraction of a unique multidimensional reality that consists of dynamic relationships between innumerable entities, traits, and phenomena.

Adopting a Scalar Perspective

Adopting a scalar perspective results in several important realizations that affect the ways in which we conduct archaeological research. First, to study and understand culture and the factors that result in culture change, we must accept the universal coexistence of pattern and variation. Therefore, culture, like nature, must be viewed as a combination of unique, individual events and composite patterns. A second important insight is that variability is an inherent condition of the natural world. Indeed, from an evolutionary point of view, variation is essential for survival. Consequently, in examining the material residues of human cultural behavior we should not expect strict uniformity, but instead should expect to encounter variation in both the material record and in the behaviors that they reflect. From this it follows that there is no single, correct scale at which to conduct archaeological analysis. Different scales of analysis provide different kinds of answers, and connecting the answers that explain patterns at one scale requires models that may, of necessity, mask or inhibit the study of variability inherent at finer scales. Thus, many different types of analysis conducted at variable scales of space and time must be pursued to approach complete understanding.

Despite the inherent difficulty of incorporating specificity and generality into a single explanatory model of culture change, I believe that it is possible to integrate a number of different models (or, if you will, scalar perspectives) within a single, unified theoretical framework. This framework that I refer to is neo-Darwinian evolution because only a selectionist theory of culture can explain how variability leads to pattern, and so provides a means for integrating the various scales of patterning and change that we observe empirically. Timothy Earle (1991a) has put forth a strategy for accomplishing this by integrating three levels of rationality into his research (Earle 1991a:85-89). Economic rationality is related to how people attempt to satisfy their basic needs -- food, shelter, and reproduction. Cultural rationality refers to the ability of people to model their behavior based on the success of others. These successful behaviors are often "traditional" ways of doing things that may not always appear rational in terms of immediate costs and benefits, but because of their continued use and success, they reduce the personal cost of experimentation. Finally, evolutionary rationality refers to decisions that are based on maximizing reproductive success; for example, decisions that increase the success of child rearing.

Although Earle does not specifically discuss scales, it is clear that his various kinds of "rationality" represent levels of increasing scalar complexity. He recognizes, for example, both the autonomous nature of the individual as well as the necessity for group association; he identifies individuals as rational decision-makers who also are subject to the values of the cultural systems that they participate in; and he relates all of these to the Darwinian notion of reproductive success. Thus, by recognizing the overlapping nature of decision-making, which occurs on a number of different scales, the model attempts to address the multicausal nature of human behavior which is the result of a complex interaction between genes, environment, learning, and individual choice (cf. Winterhalder and Smith 1992:15).

Identification of Effective Scale

As the above discussion implies, specifying the effective scale at which one is working is critical to the development and evaluation of a specific research strategy. In this study, I was concerned primarily with identifying organizational responses to limited resource availability, determining how these varied geographically and temporally, and understanding the factors that resulted in these strategies being selected for. Consequently, the scales of analysis with which I chose to work are relatively large. Geographically, I have chosen a regional scale of analysis, focusing on south Florida and, more specifically, the Kissimmee region, which encompasses both the Kissimmee River valley and the Lake Wales Ridge. This region was chosen because it is one of the few archaeological regions in Florida where the prehistoric inhabitants did not have direct access to durable raw materials such as chert, marine shell, or sharks' teeth. To provide a means of comparison, I have also included data from archaeological sites outside of my primary study area, specifically the Peace River valley, the southwest coast, and the chert-rich regions of west-central and north-central Florida.

Temporally, I have chosen to focus on two, broadly defined cultural periods -- the Archaic and post-Archaic. The rationale for choosing such large units of time are partly methodological and partly theoretical. Methodological issues are discussed more completely in Chapter 7; however, it is sufficient to state here that shorter temporal scales were difficult to identify archaeologically at many of the sites that provided lithic data for this project. This made the rather coarse-grained temporal distinction used in this study the only viable alternative for examining diachronic trends. This two-period separation does possess validity beyond the limitations of method in that existing paleoenvironmental and archaeological data from south Florida indicate substantive differences between the two periods in terms of environmental and climatic conditions, as well as settlement and subsistence strategies (see Chapters 3 and 5). Specifically, the availability of extensive marsh and wetland habitats after about 3500 B.P. appears to have contributed to the adoption of a more sedentary lifestyle in the interior of south-central Florida. This shift from a relatively mobile settlement strategy to one of sedentary or semi-sedentary existence provided an opportunity to include differential residential mobility as a variable in the temporal analysis.

These changes in climate and environment, and the corresponding settlement and subsistence strategies that were employed in response to these changes, are important factors in the consideration of changing organizational strategies since the geographic distribution of lithic raw materials has remained unchanged since before humans first arrived in Florida nearly 12,000 years ago. Differential access to lithic resources through time is a function of: 1) physical factors such as erosion, exposure, and in some cases, inundation by rising sea levels, and 2) cultural factors such as over-exploitation, the establishment of political territories, the development of exchange systems, and settlement mobility. Because they act at temporal scales that exceed the life spans of individual humans, the effects of physical processes on human procurement strategies are relatively minor in comparison to the effects of cultural practices.

The mobility strategies that were employed prehistorically by humans moving across the landscape to exploit the natural environment are perhaps the most important of these cultural factors. Because subsistence and raw-material resources are distributed unevenly in the environment, any single settlement location will provide direct access to some resources while at the same time reducing access to others. Highly mobile populations could structure their settlement patterns to provide access to necessary resources, including lithics, on a periodic basis. Less mobile populations, on the other hand, were required to situate their settlements in locations that maximized access to critical resources such as permanent water or abundant and dependable food sources. Consequently, access to other, less critical but equally important resources may have been restricted. The development of exchange systems and political territories can be explained, in part, as attempts to gain access to resources not available in the immediate environment, or alternatively, to restrict access by others to locally available resources. Thus, the examination of the organizational strategies employed in chert-poor areas becomes closely entwined with settlement variability and aspects of the regional ecology.

The Conceptual Basis

Environmental Structure

The focus on lithic resources might ordinarily place a study such as this in the general category of "technological studies" I view it, however, as intrinsically ecological and economic in nature because I emphasize the importance of environmental structure in terms of its influence on changing strategies of resource procurement and technological organization (cf. Bouseman 1993; Collins 1975:20). The physical properties of a raw material, its geographic distribution, as well as abundance and availability are the relevant environmental factors that affect procurement strategies, assemblage content, and variability in the organizational properties of a technology. Understanding the geological and geographic parameters of the resource base is thus critical to any study of lithic resource use (May

1980). However, in order to integrate studies of technological organization into an understanding of evolutionary change, it also is necessary to incorporate information on the abundance and availability of subsistence and other resources since these influence the larger sphere of economic strategies of which technology constitutes one part.

In a general sense, structure refers to a complex system which by definition is composed of many parts, arranged together in some organized way. Thus, environmental structure consists of the interrelationships between climate, topography, hydrology, flora and fauna, and raw-material distribution. Variability in environmental structure occurs at a number of different scales of space and time, and so affect human populations differently. Higher-order variability, such as long-term fluctuations in climate and precipitation within a geographic region that occur over several millennia may not be observable within the lifetimes of individuals, but may be important for studying evolutionary processes of human populations over time. Lower-order variability, such as the day-to-day or year-to-year patterns of rainfall, is more likely to affect the choices individuals make (Butzer 1982:24). These individual decisions provide the behavioral variability on which selection acts. The aggregate effect of human choices within the context of environmental structure results in adaptation via the mechanism of selection.

Jochim (1981:8-9) has observed that critiques of ecological studies in anthropology have tended to operate under two misconceptions. The first is that "environment" is restricted to the physical, natural environment, i.e., climate, weather, landscape, and exploitable natural resources. The second is that an ecological study is restricted to descriptions of food-getting behavior. Both of these assumptions are erroneous. The definition of environment that is used here follows that proposed by Winterhalder and Smith (1992:8): "...environment is defined as everything external to an organism that impinges upon its probability of survival and reproduction. The effects can bear on development, physiology, or behavior, and their sources can be physical, biological, or social." Thus, the environment consists of both the natural and social environment, and any ecological study must account for the various interactions between individuals in a population as well as the interactions between the population and the physical environment in which it exists. Furthermore, as Jochim (1981 8) notes, "ecology is the study of dynamics." It focuses on how human behavior responds to an environment that is constantly changing. Because humans must make decisions based on perceptions of their effective environment, ecology attempts to identify those factors in the external environment that are most important in influencing the decision-making process

The focus on prehistoric decision-making in an ecological context forces us to confront the problem of "objective" versus "cognized" perceptions of the environment. While the cognized perceptions of the individual participants of a social group are important elements of any ecological study (e.g., Johnson 1982), these may be difficult to identify archaeologically. A more plausible strategy is to attempt to identify the decision-making processes of the participants in a culture (e.g., Mithen 1990). An alternative approach is to take an objective perspective and apply general models of human decision-making that can be compared cross-culturally. This is the strategy that is used in this study.

The Ecological Approach

The application of ecological concepts to the study of cultural behavior has a long history in anthropology and archaeology (Bettinger 1991; Harris 1968), but its emergence as a distinct research strategy is credited to Julian Steward who developed the field of study known as "cultural ecology" (Steward 1955). Cultural ecologists assume that environmental adaptation is dependent on the nature of the available technology, the needs and structure of the society, and the specifics of the local environment. The goal is to determine whether these adaptations initiate concomitant changes, or "transformations," in the social structure and whether these changes are evolutionary in nature (Steward 1977:43). The cultural-ecological paradigm was embraced by anthropologists and archaeologists of the

1960s and 1970s who incorporated it into a systemic view of culture and cultural evolution (e.g., Binford 1962; Clarke 1978; Flannery 1968, Lee 1968; Plog 1974; Vayda 1969).

While the application of a cultural-ecological perspective resulted in many important insights into human cultural behavior, it suffered from the fact that it was essentially a functionalist paradigm. In classic functionalism, the role that social behaviors play is to maintain the structure and viability of the social system. In cultural ecology, function is replaced by adaptation, and the role that certain behaviors play is to maintain the viability of the social group within a particular environment. Thus, cultural-ecological arguments were often circular; if behaviors existed and persisted, they must have done so because they were adaptive. There were no criteria for evaluating whether or not (or the degree to which) certain behaviors are, in fact, adaptive; nor was there any way to evaluate whether behaviors are nonadaptive or maladaptive (Bettinger 1991:57-58; Smith and Winterhalder 1981:3).

Cultural-ecological research strategies also tended to assume that culture is a steady-state system and that all sources of change are external to the system (e.g., climatic change, population growth). However, as recent reviews of evolutionary theory have pointed out, a systems approach that assumes equilibrium is inappropriate to study evolutionary change (Bettinger 1991; Dunnell 1980; Wenke 1981). Not only does it fail to identify the mechanisms of change, that is, how change actually occurs within a sociocultural system, it ignores the role of the individual as an agent of change. This last complaint is often accompanied by charges of ecological or technological determinism and biological reductionism (e.g., Conrad and Demarest 1984:207; Robarchek 1989).

The most recent utilization of an ecological research strategy is the field of evolutionary ecology. According to Winterhalder and Smith (1992:3), evolutionary ecology is "the study of evolution and adaptive design in an ecological context." The field has its origin in biology and has only recently been applied to human cultural behavior. Its practitioners apply natural selection theory in an effort to explain the evolutionary development of human behaviors, and so attempt to utilize the same explanatory principles that underlie biological evolution According to Bettinger (1991:154), evolutionary ecology incorporates the contradictory concepts of change and stability into a single, coherent theory. Unlike sociobiology, evolutionary ecology does not require that behaviors be genetically determined. It requires only that behaviors that affect individual fitness must be guided by the principles of natural selection (Bettinger 1991:154; Winterhalder and Smith 1981:6). It does assume a capacity for adaptive decision-making and it further assumes behavioral variability, which is necessary for evolution and adaptation to occur. Significantly, Winterhalder and Smith (1992) emphasize that:

> ...most behavior is a result of evolutionary mechanisms and processes operating at several scales of space and time. Behavioral responses, especially those involving learning, are most likely when the relevant environment has qualities of high variance, novelty, and unpredictability...The spatial and temporal pattern of the relevant environmental features must be characterized with appropriate variables and in sufficient detail to capture these qualities...[Evolutionary ecologists] predict diverse and flexible behavior, contingent on localized and often changing conditions. The great variety of states possible in an organism's immediate environment leads behavioral ecologists to expect corresponding variety in the expression of behavior [Winterhalder and Smith 1992:9; emphasis in original].

Economic Decision-Making

Burling (1962) defines economic behavior as that which allocates limited means (resources) to achieve unlimited wants, needs, or desires. "Economics defined in this way has no necessary connection with the use of money or material objects. Since we are disposing of scarce means in virtually everything we do, economics in this view focuses on a particular aspect of behavior and not on certain kinds of behavior" (Burling 1962:810-811; emphasis in original). The aspect of behavior that Burling refers to is "choice." Since it is not possible for people to utilize their limited resources to satisfy all of their desires, choices must be made regarding the differential allocation of resources to obtain specific wants or needs. This makes scarcity a fundamental concept in economics (Glahe and Lee 1989:2-3) since it affects perceptions of value as well as allocation choices.

According to neo-classical theories of economics, value is created by supply and demand, and is market-driven; in other words, the ability of a consumer to freely choose among purchasing alternatives affects the exchange value of the commodities being offered (Baber 1987:48). On the other hand, Marxism claims that the value of a good is defined, in part, by the amount of labor time invested in its production (Baber 1987:54). The position taken here is that both theories present models of economic behavior that are approximations of reality, and both are useful for understanding economic decision-making. More to the point, a theory of labor value can be accommodated easily within a supply-and-demand model if Burling's definition of economics is accepted. Labor time is a resource that is limited in its availability and must be allocated among competing tasks (e.g., Smith 1979; Winterhalder 1983). If we choose to use our resources to conduct a certain task, we are simultaneously choosing to forgo the benefits of performing another task. The value of this "sacrificed consumption" is the opportunity cost of the choice or decision we have made (Glahe and Lee 1989:4). The concept of opportunity cost is a critical component in understanding non-Western economic systems, specifically those of hunter-gatherers where labor time and energy are the primary forms of "currency." As several recent studies have demonstrated, hunter-gatherers must evaluate the net benefits of allocating time to activities not directly related to the acquisition of energy, such as reproduction, child-rearing, social activities, and so on, with those of foraging (Hawkes 1987; Hawkes et al. 1985; Smith 1988;

Winterhalder 1983). These decisions, in turn, affect how the products obtained through the labor effort are distributed and consumed within the society (Winterhalder 1990:10).

Models of economic behavior. According to Hirschleifer (1980), all economic problems can be reduced to two questions: 1) what factors cause or explain fluctuations in the economic environment, and 2) which of several alternative strategies will provide the best outcome? The first question is an equilibrium problem and is solved through the analysis of supply and demand. The second question is an optimization problem and is addressed through the method of marginal magnitude. Although these methods are not utilized in a formal sense in this study, the principles that underlie them are used to develop hypotheses regarding lithic resource procurement and use. Therefore, it is necessary to review their basic components and provide some illustrative examples.

Equilibrium analysis utilizes the relationship between two variables: price and quantity. Price represents the amount of one commodity that is given in return for receiving another commodity. Price, then, is equivalent to cost since it consists of that which must be given up, done, or sacrificed to obtain something else. The factors that affect the price (or cost) of a commodity and the quantities that are consumed are supply and demand. The relationships between these are shown in Figure 2. The slope of the demand curve (DD) is negative reflecting the general principle that, other things being equal, the quantity that is consumed will increase as the price or cost of the commodity decreases. On the other hand, the slope of the supply curve (SS) is positive reflecting the principle that the quantity of a commodity that is supplied will tend to increase as the price increases. Equilibrium is achieved at the intersection of DD and SS, which reflects the point at which all individuals are able to acquire the good at their desired rate and all suppliers are able to distribute their good at their desired rate. Changes in the position of the equilibrium point occur as a result of changes that occur within the economic environment, in other words, changes in supply or demand.

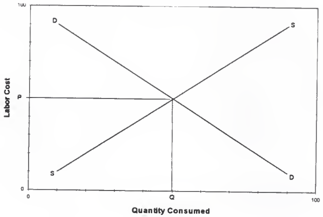
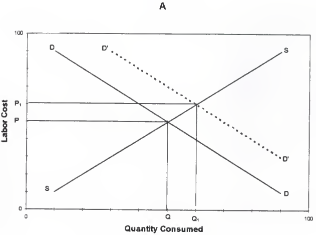


Figure 2. Generalized supply-and-demand curve.

It is possible to modify these variables (i.e., price and quantity) to consider the relationships between value, probability of use, time, energy, or distance versus quantity, utility, or preference. It also is possible to utilize equilibrium analysis to examine the effects of changes in supply and demand on the position of the equilibrium point for an economic environment in which supply is not under the control of individuals offering goods for purchase in a market-place but, instead, is dictated by the differential distribution of a desired resource in the natural environment. In Figure 3, price is represented by the labor cost (which could be measured in terms of time or energy) that must be expended to obtain a resource. Figure 3a illustrates what happens when the supply curve is shifted to reflect what occurs when a group of hunter-gatherers moves to an area where the desired resource is not available in the local environment. The new equilibrium point (P_1) defines a point at which the cost of acquisition has increased and the amount demanded has decreased as a result of increased distance to the resource



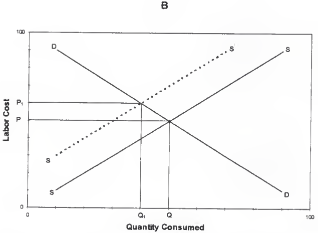


Figure 3. Supply-and-demand curves showing the effect of changes in demand (a) and supply (b).

When interpreting this curve it is important to recognize the distinction between a decrease in the amount demanded and a decrease in demand (Glahe and Lee 1989:49-50). The former is represented by a shift along the demand curve while the latter is represented by a shift in the demand curve. There has been no shift in the demand curve in Figure 3a; rather, supply has decreased as a result of moving to an area where the resource is not available. This has caused a disequilibrium in the economic environment where demand at the lower cost exceeds supply under these new settlement conditions. The increase in acquisition cost resulting from this settlement shift results in a decrease in the amount or quantity of the amount consumed, thus establishing a new equilibrium point.

The alternative case is shown in Figure 3b. Here supply remains constant. Instead, demand changes, perhaps as a consequence of an increase in population which results in an increase in consumption. Consequently, the demand curve moves to the right, along the supply curve, and a new equilibrium point is established. Disequilibrium at the initial labor cost occurred because the increased rate of consumption exceeded the supply. The greater cost at the new equilibrium point is a result of the intensification of labor effort necessary to meet the greater demand of a larger population (cf. Earle 1980:19).

Equilibrium models have wide applicability in economic analysis and they have been used to address a number of resource problems in anthropology. The supply-and-demand relationship is often implied rather than stated formally (e.g., Brumfiel and Earle 1987; Rathje 1971), perhaps because the model is conventionally presented by economists within the context of market-oriented economies. Binford (1978) uses a modified form of the classic supply-and-demand relationship to model butchering strategies among the Nunamiut (see discussion in Bettinger 1991:107-108). Similarly, Chayonov's (1966) argument that peasant households attempt to strike a balance between work and drudgery can be adapted to a supply-and-demand format (Figure 4). As the time devoted to work increases, the desire for leisure time also increases, while alternatively, as earnings increase, the desire for additional income

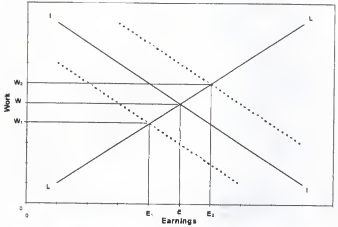


Figure 4. Equilibrium analysis of Chayanov's model of work versus leisure time in peasant societies.

diminishes. The goal of Chayanov's model is to strike a balance between work and leisure time; that is, to achieve a form of economic equilibrium. It also demonstrates the effect of opportunity cost on economic decision-making. From this model it is possible to predict under what conditions individuals will make choices to forgo leisure to increase earning or, alternatively, to forgo greater earnings to achieve more leisure time. It also is possible to examine what the effects will be on the variables of work time and earnings if there is a change in either the desire for income or the desire for leisure. The first could come about as a result of more dependents in the family, while the second could occur as a result of having to work more hours each day to support these dependents.

Demand curves also can be used to analyze and predict consumer choice between different types of goods (Glahe and Lee 1989:72-90). The variables used in this type of analysis include utility, income, and price. Utility is the level of satisfaction that an individual derives from a particular commodity. Choices are assumed to maximize utility subject to the constraints of income and price.

One of the basic assumptions of this type of analysis is that the utility derived from additional quantities of the good decreases as the amount of the good that is obtained increases. In other words, the more one has of something, the less value or utility is gained from additional quantities that are acquired by the consumer. This is known as the law of diminishing marginal utility.

Demand curves highlight two points that are important to this study: elasticity of demand subject to the constraint of price or cost and substitutability. Elasticity of demand is the change in demand that occurs as a result of a corresponding change in price (Glahe and Lee 1989:73). Elasticity of demand may change as a result of the amount of total income available, preference, or the availability of suitable alternatives. If the first two remain constant, then it is the availability of alternatives that determines elasticity. This is illustrated in Figure 5. If the price of one resource (A) increases and the quantity consumed of an alternative resource (B) also increases, the two resources are said to be substitutable. On the other hand, if the quantity of resource B that is consumed decreases as the price of A increases, then the two resources are said to be complementary. Croquet mallets and balls are an example of complementary resources while beef and chicken might be considered substitutable. In terms of lithic procurement and use, it is possible to use demand curves to observe how changes in the availability of one type of raw material affect demand for a second raw material; for example, local versus non-local stone or stone versus marine shell. This is illustrated in Figure 6 which shows the effect on the amount consumed of two substitutable commodities (resources) when the price (or availability) of one increases. As indicated, the availability of the cheaper alternative resource that can perform the same task diminishes the utility, and hence the amount consumed, of the more expensive resource.

Optimization analysis is a method for determining which alternative among a range of alternatives will supply the best outcome (Hirschleifer 1980:44). This range of alternatives can be reduced to one of three strategies: maximization, minimization, or stability (Stephens and Krebs

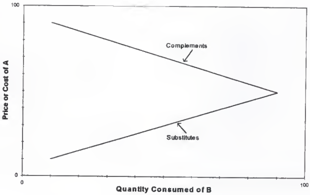


Figure 5. Elasticity of demand between two resources.

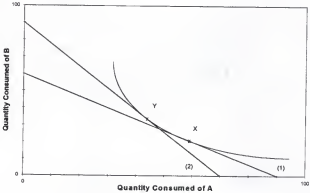


Figure 6. Effect of price or availability on the quantity consumed of two substitutable resources. An increase in the cost of resource A, as indicated by the steeper slope (2), results in a large shift in the mixture of A and B consumed (from X to Y); in other words, less of A is consumed in preference to the cheaper B.

1986:7). If the best outcome is gained by choosing an alternative that is dependent on decisions made by other individuals, then stability is the correct strategy to choose (Maynard-Smith 1982). If, however, a choice that results in the best outcome is not dependent on the decisions of others, as is the case when a forager must make a decision regarding the procurement of resources in the physical environment, then maximization or minimization principles are appropriate (Stephens and Krebs 1986:7).

These strategies assume that the individual is aware of all the alternative options that are available, knows their potential outcomes, and can accurately calculate which will prove to be the optimal choice. A fourth strategy, referred to as "satisficing," assumes that the individual does not have complete access to all necessary information and so will not act optimally. Instead, the individual will choose any alternative that will provide an outcome that is perceived as "good enough" (Smith and Winterhalder 1992b:54). However, as Smith and Winterhalder (1992b:54-55) argue, there are no objective means of determining what criteria the individual uses to determine what is "good enough." This determination can only be made by observing the individual make the decision. Therefore, all analyses that utilize a satisficing model tend to employ circular reasoning. Moreover, for evolutionary ecologists, satisficing has no meaning in terms of natural selection.

Central to the analysis of optimizing behavior is the concept of marginal value (or more generally, marginal magnitude) which is based on the relationship between Total, Average, and Marginal Returns. Average return is simply the ratio of input to output using whatever currencies are relevant to the analysis For example, input may be measured in terms of time or energy expended while output may be measured in terms of protein, calories, or volume of a procured resource. Thus, the amount of currency (output) divided by a specified unit of input (e.g., 1 hour or 500 calories of energy expended) is the Average Return. This also is a measure of economic efficiency (e.g., 500 calories procured per hour), and the inverse is the unit cost (e.g., 500 calories "costs" one hour of labor time, 250 calories "costs" one-half hour of labor time). Total Return is simply the Average Return multiplied by the total amount of input. Marginal Return is the change in total return per unit change in quantity, or in this case, labor input. Expressed mathematically, this relationship is $\Delta TR \div \Delta LT = MR$. So, if the average return for one hour of labor is 500 calories, but during the second hour the average return is only 300 calories, the total return is 600 calories (300 x 2 hrs), but the marginal return is only 100 calories (600-500=100; 2 hrs - 1 hr = 1; 100/1=100). In other words, the net return for the additional hour of labor is only 100 extra calories.

Because total returns are a function of average returns, as the average return rate decreases so too does the marginal rate of return, even though total returns may continue to rise. Another way of saying this is that decreasing marginal returns reflect a slower rate of growth in total returns due to a reduction in labor efficiency. The point at which average and marginal returns begin to decrease is called "the point of diminishing returns" and it is illustrated graphically in Figure 7. Beyond this point it is no longer beneficial to increase labor costs because for each additional unit of time expended at the increased cost, the rate at which the total net return increases begins to diminish rapidly. If labor costs continue to increase without a corresponding increase in total output (i.e., if the average return rate continues to decrease), marginal returns will eventually equal 0 and total returns will begin to decrease.

Optimization analysis uses this method to evaluate when an individual should switch economic strategies in order to maximize his or her net rate of return. Typically, a switch should be made when the marginal return for the existing strategy is equal to or less than the average return for the alternative strategy. This is based on the assumption that maximization of returns and economic efficiency are the goals; however, the method can also be used to evaluate the costs associated with different strategies rather than returns. In this type of application, the inverse of Average Returns (i.e., unit cost) is used to calculate Total and Marginal Costs.

An example of this type of application is the work of Earle (1980). Operating under the assumption that foragers and primitive horticulturists, when confronted with economic choices, will choose those strategies that tend to minimize costs, Earle compares the marginal costs associated with

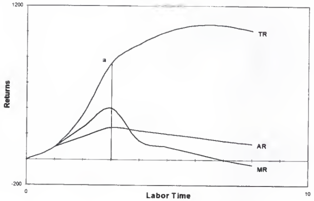


Figure 7. Graph of diminishing marginal returns. As the average return per labor hour (AR) decreases, so too does the marginal return (MR), even though total returns (TR) continue to rise. The optimal labor effort, indicated by (a), is the point at which average and marginal returns are at their highest.

three different subsistence strategies (hunting, collecting, and horticulture) to predict what mix of strategies will provide the necessary nutritional requirements at the lowest cost. Given changing conditions, such as an increase in population, the optimal mix of strategies may also change in response to new levels of nutritional demand. Earle's analysis suggests that when this occurs, the strategy mix that will be chosen will be the one in which the rate of increasing average costs is lowest.

Evolutionary ecologists employ optimization analysis in optimal-foraging theory under the assumption that the goal of individual decision-making is to increase fitness in an evolutionary sense. There are a number of different models that have been developed using optimization principles to examine specific problems associated with human and non-human foraging. Excellent overviews are presented in Bettinger (1991), Smith (1983), Smith and Winterhalder (1981), Stephens and Krebs

(1986), and Pyke et al. (1977). I will focus here only on those models that contain elements applicable to lithic procurement and use

The two most widely used models are the diet-breadth and patch-use models. The diet-breadth model assumes that resources are evenly distributed in the environment and that the forager encounters these resources at random. It also assumes that foragers rank their prey in terms of the handling costs necessary to procure them versus the net energy return yielded. This relationship is usually stated formally as $E \div T_h$, where E = gross energy acquired minus energy expended and T_h = the time required to pursue, capture, and consume the prey (Bettinger 1991:86). Time devoted to searching for the prey is not included in determining the rank of the resource, but it is included in the decision to capture an encountered prey. The model predicts that a prey will be chosen to be in the optimal diet if the marginal energy return is equal to or greater than the average return for all higher-ranked prey. In other words, if the ratio of energy return to handling time for a prey that has just been encountered (i.e., the forager's marginal return) is greater than the ratio of energy return to handling time plus the additional search time necessary to locate another prey, then the encountered prey will be included in the optimal diet. The more prey types that are included in the diet, the more likely it is that suitable prey will be encountered, and so search time associated with foraging tends to decrease. On the other hand, since prey are ranked by the amount of handling time associated with their capture, as more lower-ranked prey are included in the diet, the amount of time that needs to be devoted to pursuit and capture tends to increase. So there is a trade-off between search time and handling time: as search time decreases, handling time increases. This relationship is shown in Figure 8a. Note that what is plotted is the change in these two variables (i.e., the reduction in search time versus the increase in handling time) that is realized with the addition of an additional prey item (cf. MacArthur and Pianka 1966:Figure 1). Note also that the form of this relationship between handling time and search time is essentially that of a supply-and-demand curve (compare with Figure 3). In Figure 8b a decrease in handling time results in

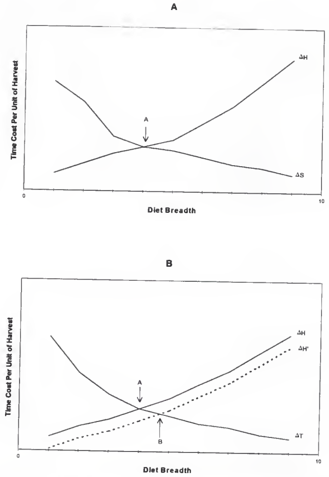


Figure 8. Graphic representation of the diet-breadth model (after MacArthur and Pianka 1966:Figure 1): a) As search time (ΔS) decreases, handling time (ΔH) increases. The optimal foraging strategy (A) is achieved at the point where the addition of an additional prey species would increase handling time more than it would decrease search time; b) Effect of decreasing handling time on the optimal strategy. Here changes in the forager's ability to pursue, capture, and process resources more efficiently increases diet breadth from A to B and decreases time spent per unit of energy.

a change in the equilibrium point such that the time per unit of energy obtained (i.e., cost) decreases and diet breadth increases even though search time remains the same. This is an important consideration for human foragers who are able develop more efficient techniques for decreasing the amount of handling time associated with specific resources.

The patch-choice model (McArthur and Pianka 1966) is slightly different in that it assumes that resources are not distributed evenly in the environment; in other words, they are clumped together in resource "patches." Nor are they encountered randomly. The resource patches are known to the forager, who is able to calculate the amount of time it will take to travel between patches to exploit the resources there. Unlike the diet-breadth model differential depletion of resources in a patch can cause that patch to be excluded from the foraging itinerary because increasing exploitation results in a decreasing rate of return. The patch-choice model is a more realistic characterization of human foraging for lithic resources since these are immobile, geographically localized, and subject to depletion. Figure 9 graphically illustrates the patch-choice problem. The basic elements are similar to the diet-breadth model: resource patches are ranked in terms of handling time, and there is a trade-off between declines in the forager's marginal return (returns per unit of handling time) in patches of lower rank versus the time necessary to travel between patches. Charnov (1976) refined the patch-choice model further by applying the marginal-value theorem to determine when the forager should decide to leave one patch and move to another. This should occur when the rate of return in the patch drops to the average overall rate that is obtainable from the environment as a whole when travel between patches, search within patches, and handling costs are included (Figure 10).

The central-place-foraging model (Orians and Pearson 1979) represents a further refinement of the basic diet-breadth model wherein foraging is modeled as a trip from a specified point (central place) to a resource patch and return. The round-trip travel time is included in the analysis of costs and benefits. The model predicts that as round-trip travel time increases, the time spent foraging in the

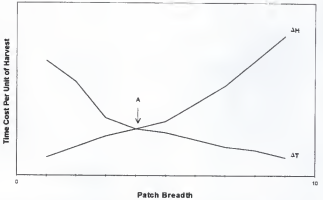


Figure 9. Graphic illustration of the patch-choice model (after MacArthur and Pianka 1966:Figure 2). Resource patches are added to the foraging inventory as long as the decrease in between-patch travel time (T) is greater than the increase in within-patch foraging time (H). The optimal strategy (A) is achieved when the inclusion of an additional patch would increase search time within patches more than it would decrease travel time between patches.

patch and the minimum acceptable prey size should all increase accordingly in order to offset the extra travel cost. If traveling time is reduced to zero, a forager should take any prey that is encountered. These predictions assume that there is no handling time involved nor do they include calculations of transport load of the return trip as a cost. Additional refinements add these variables into the analysis.

For the first of these modification, the authors conclude that for short travel times, the forager should choose those prey that provide a higher return in terms of energy per unit of handling time, while for long travel times, higher-energy prey should be taken regardless of travel time. This conclusion is based on the inclusion of travel time into the energy equation which increases total foraging time and so necessitates that higher-energy resources be taken. Prey are ranked according to the mathematical relationship $E = C \div T_t + T_h$, where E = energy return rate, C = net calorie content, T_t = travel time, and

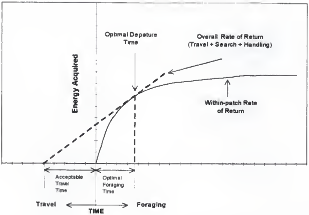


Figure 10. Application of the marginal-value theorem to the patch-choice problem (after Charnov 1976). For a given patch, the rate of energy return is a function of time spent foraging within the patch. As resources within a patch become increasingly rare, within-patch foraging time increases and the rate of energy return decreases. The optimal point at which the forager should leave the patch occurs when the within-patch rate of return drops to the overall rate of return obtainable from the environment as a whole when all travel, search, and handling times are considered.

T_h = handling time (Orians and Pearson 1979:162). As the authors note, this formula is essentially the same as that for ranking prey under non-central-place foraging theory except for the addition of travel time. Therefore, the same prey type may be ranked differently or considered more or less profitable, depending on distance from the central place (Stephens and Krebs 1986:54-55). This is illustrated by a simple example of two foragers exploiting the same resource type at different distances from the central place. For Forager 1 with a long travel time, $C_1 = 500$, $T_{h1} = .5$, $T_{t1} = 1.5$, and $E_1 = 250$, while for Forager 2, with a short travel time, $C_2 = 500$, $T_{h2} = .5$, $T_{t2} = .5$, and $E_2 = 500$ Because of shorter travel time, Forager 2 can capture a prey with $C_2 < C_1$ and still maintain a high net rate of energy return relative to handling costs: $C_2 = 300$, $T_{h2} = .5$, $T_{t2} = .5$, and $E_2 = 300$. But, if handling time increases substantially, then $E_2 < E_1$, for example: $C_2 = 300$, $T_{h2} = .75$, $T_{t2} = .5$, and $E_2 = 240$. In the extreme case, where $T_t = 0$, the ranking of prey should be based solely on the ratio of net return to handling time.

In terms of optimal load, and assuming that patch quality (i.e., abundance of highly ranked resources) is held constant, Orians and Pearson (1979:164) suggest that both the size of the load and the time spent foraging in a patch should increase with increasing distance to the central place. However, more distant patches should not be utilized until the load increases to a point sufficient to compensate for the greater travel time (Orians and Pearson 1979:166). If distance is held constant, and patch quality is variable, then the time spent foraging in patches with high resource abundance should decrease, although the optimal load may increase slightly.

These theoretical explorations indicate that for central-place foragers, decisions regarding resources are dependent on the net return of each resource relative to both travel and handling time (Bettinger 1991:96). Where travel time is low, handling time is more important because travel costs are not great enough to affect the ratio between net return and total acquisition time. On the other hand, when travel time is relatively great, handling time becomes increasingly less important and package size increases in importance.

Finally, Orians and Pearson (1979:170) predict "if maximization of rate of energy delivery to a central place is the sole criterion influencing selection of a central place, then the optimal central place is one that minimizes travel time, that is, the site that lies at the 'center of gravity' of the food distribution." In other words, cost minimization, in terms of travel time, is an optimal strategy for maximizing the rate of return, a conclusion that mirrors those of anthropologists who have studied hunter-gatherer settlement and subsistence strategies (e.g., Hayden 1981, Lee 1979, Yellen 1976).

Time allocation. Yet another application of economic models which is applicable to this study is the concept of time allocation. This has been referred to briefly above with regard to the concept of "opportunity cost." Schoener (1971) introduced the notion of time allocation to optimal-foraging studies when he considered two limiting cases to the general model of stationary, as opposed to mobile, foragers maximizing their rates of net energy returns: time minimization and energy maximization (Schoener 1971:376). *Time minimizers* are animals that attempt to maximize fitness by limiting the amount of time spent feeding to acquire a given energy requirement. Alternatively, *energy maximizers* attempt to maximize fitness by maximizing the net energy acquired over a given time period. Smith (1979) rephrased these concepts in terms of energetic efficiency and applied them to human foragers. According to Smith (1979:62), in environments where the net energy available to the forager is limited, fitness can be increased by increasing the net rate at which energy is captured over a given time period (i.e., energy maximization). In situations where time, but not energy, is a limiting factor, his model predicts that fitness can be increased by reducing the amount of time necessary to capture a given amount of energy (i.e., time minimization). By minimizing the time allocated to energy capture, more time is freed to devote to other activities that may serve to increase the adaptiveness of the forager (Smith 1979:63).

Smith (1979:61) demonstrates mathematically that regardless of which strategy is employed, the result is the same: an increase in the net rate of energy return. For example, where E_n = net energy gain (i.e., energy acquired minus energy expended, or $E_a - E_e$), T_a = time required to acquire E_a, and R_n = net acquisition rate (or $E_n \div T_a$), then let $E_n = 10$, $T_a = 2$, and so $R_n = 5$. For a forager practicing a strategy of time minimization, decreasing T_a results in an increase in R_n: $10 \div 1 = 10$. Similarly, for a forager practicing a strategy of energy maximization, increasing E_n results in an increase in R_n: $20 \div 2 = 10$. By transposition, the equation $R_n = E_n \div T_a$ becomes $E_n = (R_n)(T_a)$. Smith (1979:62) relates this relationship to fitness under the assumption that an increase in E_n will lead to an increase in fitness and, therefore, fitness can be increased by increasing either R_n (the net rate of acquisition) or T_a (the time devoted to acquiring energy). However, because more time spent acquiring energy necessarily results in less time spent conducting other activities (T_o), there reaches a point where fitness begins to decrease as T_a increases and T_o decreases.

This last point focuses on the opportunity costs and benefits of adopting the two different strategies. Winterhalder (1983) expanded on this by using indifference curves to demonstrate that time minimization and energy maximization are simply two poles at either end of a continuum of behavioral options that balance the trade-off between time and energy. This enabled him to predict under what conditions foragers should adopt one or the other strategy (Winterhalder 1983:78-81). When only a small increase in energy gain is required to compensate for a large decrease in non-foraging time, then the forager is said to be energy-limited. Conversely, when a large increase in energy gain is required to compensate for a small reduction in non-foraging time, the forager is said to be time-limited. For foragers that are time-limited, the optimal strategy is to decrease the amount of time spent foraging as high-ranking resources become more abundant in order to obtain the same or greater intake. This leaves more time available for non-foraging activities. For foragers that are energy-limited, the optimal strategy is to increase the time spent foraging and increase diet breadth as high-ranking resources become more abundant. In other words, energy-limited foragers should forage longer, while time-limited foragers should dispense with foraging chores more quickly.

Finally, Hames (1992) introduced the effect of technology into the time-allocation problem by observing that tools that reduce the amount of time devoted to activities or increase total production would increase the rate of energy return. He predicted that if a new technology resulted in a reduction in time spent in energy acquisition without an increase in production, the group could be considered time-limited, but if the new technology increased production without a corresponding reduction in the allocation of time, then the group could be considered resource-limited (Hames 1992:218-219).

Summary. Based on the preceding review, the following economic principles have been extracted. I consider these principles to be the most relevant for a study of lithic-resource procurement and use, and they are used in subsequent sections to develop hypotheses for testing against the archaeological record of south Florida.

1) As the cost of acquiring a resource increases, the quantity demanded or consumed decreases.

2) The elasticity of demand for two resources is based on available income, preference, and differential availability. If the quantity consumed of one increases as the price, preference, or availability of the other increases, then the two resources are substitutable. If the quantity of one decreases as the price, preference, or availability of the other decreases, then the two are complimentary.

3) Value can be conceived of as the result of a combination of supply, demand, and availability of alternative resources. Where demand for a commodity is high but supply is low, the commodity is likely to be more highly valued. However, if a suitable substitute is available, then the value of the commodity in limited supply may diminish.

4) The cost of procuring a resource from the natural environment consists of a combination of travel and handling costs. The latter includes search, procurement, and consumption costs.

5) As the abundance of highly ranked resources in an environment increases, resource breadth should decrease resulting in a specialized resource mix. Alternatively, as the abundance of highly ranked resources decreases, resource breadth should increase resulting in a generalized resource mix.

6) An increase in the use of lower-ranked resources decreases search and/or travel time, but increases handling time.

7) A reduction in handling time can offset the costs of traveling between resource patches.

8) For central-place foragers, as distance to a resource increases, package size is more important than handling time. Alternatively, for central-place foragers who live in close proximity to a resource, handling time is more important. For both, the optimal strategy is to choose the resource that provides the highest return per unit of time expended in procurement.

9) Where resources are limited but time is not, the forager should spend more time in the procurement effort in order to maximize the net rate of return. Where time is limited, but resources are not, attempts should be made to maximize net return over a limited amount of time in order to maximize the net rate of return.

10) The introduction of a new technology that either reduces time spent in energy acquisition or increases energy returns will result in more efficient energy extraction (i.e., increase the rate of energy return).

Critiques of economic modeling. Criticism of the use of neo-classical principles to study non-market economies abound in the literature. The substantive argument that Western formalist theories of economic behavior are inappropriate for studying non-Western economic systems (e.g., Chayanov 1966; Halperin 1994; Meillassoux 1978; Sahlins 1972) is based on the notion that economic rationality is culturally relative. However, as discussed above, the definition of economics as the allocation of limited means to achieve multiple goals or objectives requires only that: 1) individuals make choices, and 2) that these choices be based on a rational evaluation of the costs and benefits associated with different courses of action. It does not require that economies be defined in terms of money or currency, by material objects, or even by exchange relations. Time and energy are valid forms of "limited resources" that must be allocated; the attainment of status and prestige are valid goals that require decisions regarding the allocation of resources that must be made in order to achieve them. The ways in which people manipulate their limited resources to achieve desired ends or goals is what constitutes economic behavior. If this definition is accepted, then economic behavior (and attempts to economize) are likely to be found in all societies and in all facets of social life. Thus, economic behavior is not divorced or separated from other aspects of social life, it is integral to it.

A second major criticism is that neo-classical economic models contain unrealistic assumptions about how humans think and behave and assume conditions that are not often found in the real world.

Thus, they cannot hope to explain the diversity of behavior that is present. As Bettinger (1991:105) is quick to point out, this is tantamount to arguing that it is impossible to develop general theories that can be used to explain natural phenomena. All models are approximations of reality. Attempts to increase specificity to provide a model that approaches real-world situations necessarily suffer from an inability to abstract to more general applications. Thus, different models may be more appropriate for some questions than for others. Baber (1987:56-57), for example, has argued that Marx's labor theory of value is based on value perceived from the perspective of society as a whole, while the neo-classical theory of value "shifts the level of analysis from society to the behavior of the individual" (Baber 1987:57). He concludes by advocating the use of both concepts depending on the scale at which one is working (Baber 1987:67-69).

Yet a third criticism is that optimization models as they are used in optimal-foraging theory are tautological in structure (e.g, Keene 1983:145-146); in other words, they assume that optimal behavior is adaptive and that all organisms practice optimizing behavior. Therefore, the goal of optimization analysis is not to determine whether or not behaviors are optimal, but to demonstrate that optimal behavior exists. Practitioners of optimal-foraging theory counter this claim by arguing that optimization is not a hypothesis that is being tested. It is a method that is used to develop hypotheses regarding how hunter-gatherers ought to act given specified conditions. These expectations are then compared with actual behavior in order to determine whether a group is adapted or not (Bettinger 1991:105; Smith and Winterhalder 1992b:50-51; Stephens and Krebs 1986:207). By using this approach, it is possible to avoid the problem of assuming that a group is well adapted initially, and then designing a research strategy to demonstrate that this is so.

A criticism that is closer to the subject of this study is Jochim's (1989) comments on the use of optimization principles in lithic studies. In particular, he argues that the role of lithic resources as a currency is not well understood, due primarily to a lack of ethnographic studies of lithic-using peoples and the economic role of lithics in these societies (Jochim 1989:107). This is simply the cultural relativity argument all over again. For societies dependent on the physical environment to provide the raw materials necessary to extract energy from that environment, economic decisions related to acquisition of these non-subsistence raw materials constitute an important component of their economic systems. Moreover, lithic raw materials are rarely conceived of as a currency in economic analyses. They represent a resource that must be acquired from the physical environment, and that acquisition extracts a cost in terms of direct labor time as well as opportunity costs. The currencies that are most relevant for studying the economics of lithic procurement are time and energy, the same as are used in most other optimal-foraging analyses.

Jochim (1989:107-108) also argues that the selective penalties of differential lithic-resource use are not well understood and, therefore, the assumptions of evolutionary ecology may not be appropriate for lithic studies. Torrence (1989b:2) echoes this concern. However, it is not necessary to operate under the assumptions of evolutionary ecology in order to use optimization to model economic behavior, although it is true that most economic studies in archaeology (including this one) assume that adaptive processes were operative even if the assumptions are not explicit. More directly, as the studies cited above demonstrate, any economic strategy that increases cost efficiency (i.e., results in a greater output at a lower cost over a specified period of time) will tend to maximize a forager's net return rate. Since the overall time and energy budgets of human foragers are assumed to be limited, individuals who successfully employ strategies that maximize energy return or minimize the time expended to acquire energy will have a greater propensity to survive and reproduce. Thus, prehistoric hunter-gatherers confronted by changing environmental conditions would have been under strong selective pressures to choose such strategies in deference to other, less efficient ones (Smith 1983:626). If the procurement and use of lithic materials were important components of the energy-capturing economies of native peoples, and so contributed in their own way to differential fitness, and if the procurement and use of these materials entailed their own sets of costs in terms of time and energy, then human decisions to choose between alternative strategies related to raw-material procurement, tool production, and tool use should also have been subject to selective pressures.

A more germane criticism is Jochim's observation that there may be several technological responses to a specific problem. For example, tool size might decrease in response to the needs for a portable technology among highly mobile foragers, or it might increase if access to raw materials is increased. Optimization alone is not sufficient to predict which of these factors was, in fact, operable; additional information is needed to make this determination (Jochim 1989:108). Consequently, Jochim advocates a research strategy in which multiple lines of evidence are examined to arrive at a complete understanding and explanation of lithic-resource use (Jochim 1989:108; see also 1983:167).

Certainly, a multidimensional approach to studying the past is most desirable, as the extended discussion of scale has emphasized. However, Jochim's cautionary argument is based on what he perceives as the uncritical use of economic principles in lithic studies. What is needed is the development of theories of lithic-resource use that are derived from general economic principles, but which do not apply these blindly without considering the special properties and characteristics of the commodity itself and its use in prehistoric societies. An example of an attempt to develop such a theoretical framework that is specific to lithic resources is Odell's (1996) discussion of the appropriate archaeological indicators for determining the effects of differential mobility strategies versus raw-material availability on lithic economies. Another is Bouseman's (1993) attempt to examine the fitness benefits of different technological strategies under the assumption that the use of technology by human foragers can affect search and handling times associated with subsistence pursuits. Furthermore, the time allocated to tool production and maintenance must be balanced against the costs of foraging for food. If two technological strategies have different production and maintenance costs, then assuming that the rate of energy return remains constant, the technological strategy that is less costly in terms of time allocation should offer the greatest fitness benefit (Bouseman 1993:63).

Economics of Lithic-Resource Use

Cost and Risk

Recent research indicates that variation in the organizational structure of prehistoric lithic assemblages was influenced to a large degree by the availability and abundance of lithic raw materials (e.g., Andrefsky 1994a, 1994b; Bamforth 1986; Dibble 1991; Francis 1983; Henry 1989; Kuhn 1991; Marks et al. 1991; Newman 1994; Odell 1989a; Thacker 1996). These studies assume that when resources are perceived to be limited, people will exploit and utilize them differently than if they are perceived as abundant. They further assume that, in general, hunter-gatherers will adopt least-cost, least-risk solutions to problems of resource procurement. Both of these assumptions appear to be valid ones based on theoretical considerations of optimal foraging (see discussion above), as well as ethnographic data of modern foragers and horticulturists (e.g., Cashdan 1990; Halstead and O'Shea 1989a; Hayden 1981; Johnson 1982, 1990; Johnson and Earle 1987; Kelly 1995; Lee 1979; O'Connell and Hawkes 1981). Furthermore, we should expect that since time and energy budgets are limited, additional expenditures of these currencies resulting from an increase in demand for lithic materials or a decrease in supply resulting from limited availability would result in alterations to various aspects of raw-material acquisition, tool production, use, and maintenance in order to contribute to a more efficient processing of the available time and energy (Torrence 1989b:3).

In non-market economies, the principal cost is labor or energy expenditure, for which time or distance can be used as proxy measures. For example, the costs associated with direct procurement of lithic resources include the search time associated with locating outcrops containing suitable lithic materials, time spent traveling to and from lithic outcrops once they have been identified, and handling time associated with the actual procurement and processing of the raw material which eventually results in a functional implement.

Binford (1979; Binford and Stone 1985) has argued that the costs associated with acquiring these materials should be minimal because their procurement would have been embedded in other activities. In the terminology of economics, the opportunity costs associated with lithic resource procurement would be reduced by such a strategy. In a similar vein, Torrence (1983:12) has proposed that time stress resulting from the need to conduct other, non-technological activities can be reduced by embedding lithic procurement in subsistence activities. However, embedding lithic procurement in other activities only minimizes costs, it does not eliminate them (Francis 1983:22-23). Transport costs also are a function of load; that is, the energy cost of transporting a load of specific size and weight (Jones and Madsen 1989; Schoener 1971). The ability of individuals to transport lithics would have been constrained by the amount that could be carried by hand or in some sort of container. If lithic procurement was embedded in other subsistence activities, then the amount of stone transported would have been further constrained by the need to transport other subsistence items. The amount of subsistence goods transported also would have been limited by the amount of lithic material that was required to be transported, and this would have been dependent on technological needs, or in other words, demand. For technological systems heavily dependent on stone as a source of raw material for tool production, the amount of stone required would necessarily be greater than for a technological system that utilized other, substitutable materials This combination of factors suggests that there would have been a maximum transport distance beyond which the costs of procuring lithic raw materials directly would have outweighed the benefits (Jones and Madsen 1989:530).

The degree to which embedded procurement was practiced also is related to the availability and abundance of lithic raw material. If a group resides in or visits an area of abundant raw materials, then transport costs may well be minimized by embedding procurement in other tasks; however, in an area

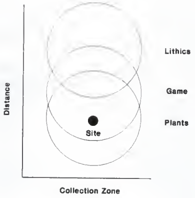


Figure 11. Graphic representation of different resource-procurement zones.

of few or no lithic raw materials, transport costs can become significant (Bamforth 1986). Furthermore, embedded procurement of lithics is dependent on the subsistence organization of the society, and is a viable strategy only when the distribution of lithic resources overlaps the effective range of exploitation of at least one other resource (cf. Kuhn 1989:39). This relationship is illustrated in Figure 11 where hypothetical collection zones for three different resources -- plants, wild game, and lithic raw materials -- are represented by three concentric circles. Where the distribution of lithic resources overlaps the effective range of collection for plants, game, or both, embedded procurement of stone is likely to occur since travel costs can be averaged out between all collected resources. When lithic resources are located beyond the collection range of other desired resources, special trips must be made to obtain only stone and the advantages of embedded procurement diminish. Thus, the planning necessary to acquire lithic raw materials, and the costs associated with their transport, increase as resources become less available, that is, as distance to lithic source areas increases.

Risk also is a major consideration among hunter-gatherers (Smith 1988; Winterhalder 1986). With regard to lithic resources, risk can be conceptualized as the potential for failing to obtain necessary raw materials for tool production, while uncertainty refers to the absence of information regarding the distribution and availability of raw materials. Bouseman (1993:64) notes that distinguishing archaeologically between the effects of risk and uncertainty may be difficult, and he has collapsed the two under the general term "risk."

Risk and uncertainty are present when a population expands into a new environment where the abundance and predictability of necessary resources are unknown. Risk extends beyond the technological sphere of economics to impact the subsistence sphere as well since failure to obtain durable raw materials for tool production may result in a failure to efficiently exploit available biotic resources. Under these conditions we might expect that measures will be taken to lessen procurement risk and increase certainty.

According to Colwell (1974), predictability consists of two components: constancy and contingency. A resource with a high degree of constancy is one that is available year-round in known amounts and in a specific location. Furthermore, these conditions do not vary from year to year. A resource that exhibits variation in quantity and location on a seasonal basis is said to exhibit a high degree of contingency. Among subsistence resources, many aquatic species exhibit a high degree of constancy while some terrestrial mammals and plants exhibit a high degree of contingency. Lithic resources exhibit a high degree of temporal constancy since they are immobile and are not subject to seasonal or yearly variation in abundance or location. Their availability, however, is limited to the extent that their geographic distribution is restricted to specific geomorphic locales. Thus, they exhibit a moderate degree of spatial contingency.

Halstead and O'Shea (1989b 3-4) suggest that cultural responses to variability in the temporal and geographical distribution of resources can be grouped into four main categories: mobility, diversification, storage, and exchange. Binford's (1980) distinction between residential mobility and logistical mobility defines two extremes of possible hunter-gatherer settlement strategies that are highly influenced by environmental structure and risk-abatement concerns (cf. Kelly 1983). *Residential mobility* enables hunter-gatherers to simply move away from an area of scarcity toward an area of area of resource abundance. *Logistical mobility* enables less residentially mobile populations to send special task groups to exploit resources and return them to the residential camp. *Diversification* refers to a broadening of the resource base, either by incorporating a wider range of resource types into the inventory or by exploiting larger and more varied geographic areas. Optimal-foraging models (e.g., MacArthur and Pianka 1966; Orians and Pearson 1979; Stephens and Charnov 1982) likewise suggest that when resources are abundant (i.e., when supply is high and demand is low), foragers can afford to be selective and will choose only high-utility resources. Under these conditions, variability in the resource mix will be minimized. Alternatively, when resources are less abundant (i.e., when supply is low and demand is high), a generalizing strategy will be practiced and resource variability can be expected to increase as more and more low-utility resources are included in the procurement mix. Thus, as the potential for a lithic-resource shortfall increases, resource variability also should increase.

Storage is a means of dealing primarily with temporal variability by stockpiling a resource for use at a future time. *Exchange*, on the other hand, is used to buffer against spatial variability. Storage of perishable items is a high-cost strategy, particularly for mobile foragers, since labor effort must be expended to build and maintain storage facilities, and to prepare perishable foods to be stored (Binford 1980). Both of these factors may vary depending on the type of environment. In Florida, for example, heat and humidity would be major factors influencing the kinds of preservation techniques and storage practices that were utilized, and these would affect the overall cost of storage. Other costs include defending stores from seizure by others and the costs of reduced mobility which limits the ability of foragers to practice potentially more efficient forms of energy capture. However, for non-perishable materials like stone, storage may not entail as great a cost if raw materials, blanks, or finished tools are stockpiled or cached. Thus, in terms of lithic resources, storage is a risk-abatement strategy that can be practiced by either mobile or sedentary populations (Odell 1996:55). Exchange also has its share of costs including those related to acquiring or producing items to be used in exchange transactions, travel to and from the point of exchange, and the social and political costs of establishing and maintaining exchange relations. The bulk of these costs must be invested prior to acquisition. These "pre-acquisition" or "preproduction" costs can be offset by limiting the amount of waste material transported and/or the amount of processing time necessary to modify the raw material into a finished implement. An efficient way of achieving both of these cost-reduction goals is to acquire the raw material in a finished or nearly finished form (Morrow and Jeffries 1989:30).

Procurement Strategies

In terms of lithic procurement, there are only two principal options: direct procurement at the source or indirect procurement through exchange. Luedtke (1976:25-27) distinguishes between casual and deliberate direct procurement. Casual procurement occurs when raw materials are obtained while performing other activities, and is most common in areas where chert is relatively abundant and widely dispersed. Casual procurement tends to result in a high incidence of expedient tool use with little or no modification or maintenance of tool edges. These expectations are consistent with central-place-foraging and opportunity-cost models that suggest that when resource abundance is high, attempts will be made to minimize the time spent in procurement and handling of the resource. When resources are located nearby, travel cost is low, so handling costs are more important. Thus, attempts would be made to decrease these costs through the use of expedient processing of raw materials. Deliberate procurement involves making a special trip to a source location in order to obtain materials for performing a specific task or for manufacturing tools for future use. Since the distances traveled to obtain the necessary material can be quite great, there are limitations on the amount of material that can be transported. For this reason, only prepared cores and bifacial blanks or preforms would likely be carried back to a campsite or residence. The labor cost involved in production and transport implies that tools manufactured from deliberately procured materials should exhibit a high rate of curation. Again, these expectations conform to those of central-place-foraging and opportunity-cost models which suggest that net return rates can be maximized by procuring as much of a resource as possible over a given period of time. Processing lithic material into blanks, preforms, or finished implements increases the amount of usable raw material that can be transported (i.e., package size) by decreasing the load cost. These theoretical expectations are supported archaeologically by the studies of Luedtke (1976) in Michigan and Francis (1983) in north-central Wyoming.

Another form of direct procurement is the scavenging and recycling of previously discarded tools and production debris (Camilli and Ebert 1992; Schiffer 1987:29-30, 106-114). The degree to which scavenging will occur is also a function of supply and demand. In areas where direct access to resources is limited, scavenging behavior is expected to increase (cf. Ascher 1968). On the other hand, settlement strategies or exchange relations that increase access to lithic materials should result in a decrease in scavenging behavior. A decrease in scavenging also may be brought about by a reduced demand for lithic materials through the use of alternative raw materials such as shell, bone, or wood. According to Schiffer (1987:109), the artifacts most likely to be recycled would be those with the greatest remnant use lives, for example, intact or partially intact tool forms and larger pieces of production debris.

Indirect procurement involves the process of exchange of which Luedtke (1976:27) defines three types: exchange of valuables, exchange of utilitarian goods, and gift exchange. Exchange of valuables usually occurs within a political context and is limited to non-utilitarian or prestige goods. Exchange of utilitarian goods occurs for the purpose of obtaining materials (food or raw materials) necessary to conduct daily activities. According to Luedtke, this type of exchange is best characterized by systematic and regular trade relationships. Gift exchange occurs in the context of social relationships and is common among hunter-gatherers (e.g., Weissner 1982). While not as intensive or regular as utilitarian exchange, gift exchange can result in wide geographic distributions of materials (Luedtke 1976 42). Furthermore, as Winterhalder (1986) has shown, cooperative alliances, which may include sharing and gift exchange, are an effective means of reducing variability in the return rates of small groups of hunter-gatherers. As group size increases, however, the costs of adding new members to the group outweighs the benefits of reduced variability achieved through cooperative exchange.

As discussed above, the cost associated with exchange can be offset by importing the raw material in a finished form. While this may effectively reduce transport and handling costs associated with exchange, it can also result in inflated exchange values as producers attempt to offset their own labor costs. An alternative to the consumer is to import raw material in an unfinished form. Transport costs can be reduced by acquiring the material in small packages such as nodules, fragments, or dressed cores. Under these conditions, core-reduction strategies should be designed to either minimize the time expended in tool production or maximize the number of usable tools that can be obtained from the available material (Goodyear 1993; Johnson 1987:202).

Technological Organization

Most studies of technological organization have focused on two primary strategies -- curation and expediency. The difference between them is related to the degree of planning that each strategy represents. Generally speaking, technologies based on curation consist of assemblages of tools that are relatively sophisticated, formally distinct, and possess specialized functions. Labor time is invested in advance of the activity to be performed in order to maximize the efficient use of time during actual task performance (Binford 1979b:269; Nelson 1991:63; Torrence 1983:12). The utility of curated tools is maximized by transporting them between settlements, expending effort in maintenance and resharpening, and by recycling broken or exhausted tools (Bamforth 1986:79; Binford 1979b:263, Odell

1996). Expedient technologies, on the other hand, consist of assemblages that are relatively simple with less formal patterning and minimal alteration to the raw material. Two types of expedient strategies have been suggested by Nelson (1991:64-65). Opportunistic expediency is a response to a need that was unanticipated using whatever materials are at hand. Planned expediency is a planned response that attempts to minimize the investment of technological effort. The latter strategy is only viable when time and place of use are predictable (Bleed 1986; Parry and Kelly 1987). Both forms of expediency require that there be sufficient raw materials available so that time does not have to be spent acquiring them; however, it is especially critical for a strategy of planned expediency since the goal is to reduce the time spent in procuring, transporting, and producing tools. This can be accomplished by locating settlements near a lithic source, or by caching or stockpiling raw materials at a residential location.

Advance preparation of tools for future use involves high initial costs in terms of procurement and manufacture time. If time is invested in procurement and manufacture, then maintenance will occur in order to extend the use life of the implement and even out the initial costs of production, regardless of material availability (Binford 1979; Ebert 1979; Odell 1996; Parry and Kelly 1987). On the other hand, Bamforth (1986:40) argues that curation and maintenance should occur only when raw materials are not readily available.

If access to durable raw materials is a limiting factor in the settlement of a region, then it may be necessary to adopt differential strategies of residential mobility in order to gain access to these materials. Several researchers have argued that different types of mobility strategies will result in differences in tool diversity and specialization (Binford 1980; Ebert 1979; Shott 1986; Torrence 1983). This is due primarily to the differential need for portable assemblages and activity planning. Groups that practice a relatively mobile lifestyle (i.e., residential mobility in Binford's [1980] terms) should possess a tool assemblage that emphasizes portability and can be used to conduct a number of different tasks. Groups practicing a strategy of logistical mobility are assumed to move their residential base camps less often, thus the need for a portable tool assemblage is less. Further, the use of specialized task groups and storage facilities implies an increase in activity planning and a more structured strategy for managing time (Torrence 1983). Assuming that specialized tools are more efficient and reliable for specific tasks than generalized tools, a settlement strategy of logistical mobility should be evidenced by an increase in the use of specialized tools and, hence, an increase in tool diversity (Shott 1986). Settlement systems characterized by a high degree of residential mobility should be evidenced by tool assemblages that are more generalized and useful for a variety of functions. Furthermore, Kuhn (1989:35-36) has argued that residentially mobile foragers tend to manufacture and maintain their tools in short periods throughout the course of the year and across all settlement locations, while logistically mobile hunter-gatherers tend to "gear-up" for anticipated use of their tools during scheduled periods of time at the residential location (cf. Binford 1979). While the manufacture of specialized tools increases reliability, another strategy to increase reliability and decrease the risk of failure is to replace tools before they wear out (Kuhn 1989:36-37). Thus, the archaeological assemblages resulting from logistically mobile hunter-gatherers should exhibit worn but still functional tools that were abandoned or cached at residential locations, while those of residentially mobile hunter-gatherers should possess a larger number of exhausted tools with little residual utility remaining.

Parry and Kelly (1987) offer an alternative hypothesis for the use of lithic raw materials by groups that practice a more sedentary existence. They argue that reduced mobility results in reduced access to lithic raw materials, and that this often is compensated for by acquiring and stockpiling lithic materials at permanent habitation sites. Having a ready supply of stone on hand would encourage a casual, expedient use of the material. Consequently, unsystematic core reduction and the use of informal, expedient tools rather than curation and recycling would be expected. Expedient use of raw materials is a relatively wasteful strategy, however, and as they point out, having access to lithic materials, either directly or through exchange, is an important factor in determining whether an expedient technology will be practiced (Parry and Kelly 1987:300-301). The practice of stockpiling also implies that the future use of stone has been planned for to ensure that a sufficient supply of material will be available to meet tool-using needs until more can be acquired. As McAnany (1988:9) points out, in those technological systems where stone is acquired indirectly through exchange, the rate of acquisition may not be under the direct control of those who are most involved with tool manufacture and use, a situation that further encourages the use of economizing strategies. Thus, regardless of the practice of stockpiling, some degree of material conservation would be expected in an area with limited direct access to stone.

In light of the theoretical concepts discussed above, several hypotheses regarding lithic-resource procurement and use through time are presented in Chapter 6. First, however, it is necessary to describe the environmental, geological, and cultural contexts of the study area.

CHAPTER 3
DESCRIPTION OF THE STUDY AREA

The geographic area that is the primary focus of this study is known by archaeologists as the Kissimmee region. It is defined as that part of south-central Florida that is drained by the Kissimmee River. For the purpose of identifying specific geographic boundaries I have used the drainage basin map of Florida prepared by the U.S. Geological Survey (Conover and Leach 1975). The area includes the river's head-waters in southwestern Orange and northern Osceola counties, and extends southward to include eastern Polk County, all of Highlands County, most of Okeechobee County, a portion of Glades County including Fisheating Creek, and a small part of western Martin County, ending where the river enters Lake Okeechobee. The sites used in this study are located in the Kissimmee River valley and on the adjacent Lake Wales Ridge (Figure 12). Although primarily a geographic definition, recent archaeological research (Austin 1987, 1992a, 1993, 1996a; Austin et al. n.d.; Johnson 1991, 1994, Mitchell 1996) indicates a high degree of archaeological uniformity throughout most of the region, at least during post-Archaic times.

In addition, data from sites located in the adjacent Peace River valley, along the southwest coast, and in the chert-bearing regions farther north have been included to provide a comparison with sites in the chert-poor, south-central interior. However, since the primary focus of this study is on the adaptations of prehistoric peoples in the Kissimmee region, the environment, geology, and prehistory of this area are emphasized in this and the following chapters.

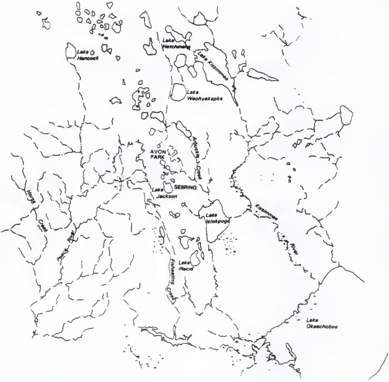


Figure 12. Map of the study area showing the Kissimmee River, Lake Okeechobee, and surrounding features.

Physical Environment

The Kissimmee region can be divided into three geographic subareas -- northern, central, and southern. The northern Kissimmee region extends from the headwaters of the river south to Lake Kissimmee; the central area extends from Lake Kissimmee to the boundary between Highlands and Glades Counties; the southern area extends from the Highlands-Glades county line to Lake Okeechobee. This geographic division follows that used by the U. S. Army Corps of Engineers (USA COE) in its recent Kissimmee River restoration environmental impact study (USA COE 1991). These subareas encompass a wide range of natural environments which would have affected the types of prehistoric adaptations practiced in each.

Climate

Water is the basic agent that shapes Florida's landscape through the processes of deposition and erosion. It also affects the type, geographic location, and extent of a region's flora and fauna. Therefore, climate and weather are important factors in understanding the environment and geology of the study area.

Florida is located at a latitude of approximately 30 degrees north (Winsberg 1990:Figure 1:3). Over most of the world, continental land masses that are located between 10 and 30 degrees north latitude are subhumid or arid. Florida's climate is different because of its maritime environment and the influence of the Gulf Stream, as well as prevailing wind patterns and the peninsula's proximity to a subtropical high-pressure zone known as the Bermuda-Azores high (Winsberg 1990:1-21). As a result, south Florida's climate is defined as subtropical with long, hot, humid summers and mild winters. The prevailing winds are southerly during the spring and summer, and northerly during the fall and winter (Carter et al. 1989:2; Jordan 1973 IIA-2). During the winter months, however, warm air from the Caribbean and lower latitudes of the Atlantic Ocean invades south Florida and prevents cold air from the continent from penetrating the southern half of the peninsula as often as it does in north Florida (Winsberg 1990:29).

Wet and dry seasons are well defined. Approximately 55 percent of the rainfall occurs between the months of June and September, and only about 10 percent occurs between December and February (Florida Department of Natural Resources [FDNR] 1974:5; Parker et al. 1955:Table 57; VanArman et al. 1984:144). The rainy season begins and ends abruptly, with twice as much rain falling in the first and last months of the season than in the preceding and succeeding months, respectively (FDNR 1974:78). Summer rains are primarily the result of convectional thunderstorms that occur as a result of the heating of the land surface and increased evaporation. During the fall months, as the land surface cools and convective energy dissipates, most rainfall occurs as a result of tropical storms. During the winter months, rainfall occurs as a result of the southward invasion of cold, polar air masses which force the warm, moist air over Florida to rise resulting, when cooled, in precipitation.

Interestingly, the Kissimmee River-Lake Okeechobee watershed experiences significantly less annual rainfall than any other area of the state except the Florida Keys, averaging only 91 cm (36 in) per year (VanArman et al. 1984:145). This may be due to reduced convection resulting from slightly cooler surface temperatures over Lake Okeechobee and up the river valley (Brooks 1974:258; Gleason et al. 1974:309; cf. Thomas 1974:88, Figure 17). Despite the low, annual average precipitation, rainfall records beginning in 1871 indicate numerous incidents of flooding and extended inundation of the basin, particularly when hurricanes followed a wet summer (USA COE 1991:A-6). This is due to two factors: 1) the large storage capacity of the lakes in the upper basin which overflow during periods of heavy rainfall and discharge into the lakes, swamps, and streams of the lower basin, and 2) the accumulation of ground water in the adjacent Central Highlands and Lake Wales Ridge which eventually discharges into the Kissimmee River and some of the larger lakes which are at a lower elevation (Kohout and Meyer 1959:17-25, Parker et al. 1955:138, 301-305).

Geomorphology

The study area encompasses several major geomorphic features (Figure 13) as defined by White (1970). The northern Kissimmee region is situated at the interface between the Central Highlands (more specifically the Orlando, Mt. Dora, and Lake Wales ridges) and the Osceola Plain. The central Kissimmee region consists of two major features -- the Osceola Plain, which contains the valley and floodplain of the Kissimmee River, and a southward extension of the Central Highlands known as the Lake Wales Ridge. The southern Kissimmee region is contained almost entirely within the low-lying Okeechobee Plain. The narrow Caloosahatchee Incline borders the Lake Wales Ridge on its eastern and southern margins. To the west of the study area is the Polk Uplands and DeSoto Plain, geomorphic features that contain the Peace River valley

The genesis of these features is largely the result of marine transgressions and regressions during the Pliocene and Pleistocene. Their modern appearance has been affected by subsequent erosion, aeolian deposition, and solution of the underling limestone. The five principal marine terraces that have been identified in the study area are listed in Table 1. Cooke (1945) and Healy (1975) identified two additional terraces: the Penholoway at an elevation of 21 m (70 ft) and the Talbot at about 12 m (40 ft). However, not all geologists recognize these features as true terraces, considering them to be standstills during either Wicomico or Pamlico times. In fact, Healy (1975) notes that the Talbot is not well represented in south Florida. They are included in Table 1 because reference to both the Penholoway and Talbot terraces do appear occasionally in the geological literature of the region (e.g., Kohout and Meyer 1959:41; Parker et al. 1955:137-140).

The Silver Bluff sea stand is based on a shoreline terrace in southeast Florida that was initially interpreted as being the result of a late Holocene transgression and subsequently was extended to other parts of coastal Florida and Georgia (MacNeil 1950); however, recent radiocarbon dates indicate that the Silver Bluff terrace is Pleistocene in age (Cronin et al 1981). While the Silver Bluff may not be

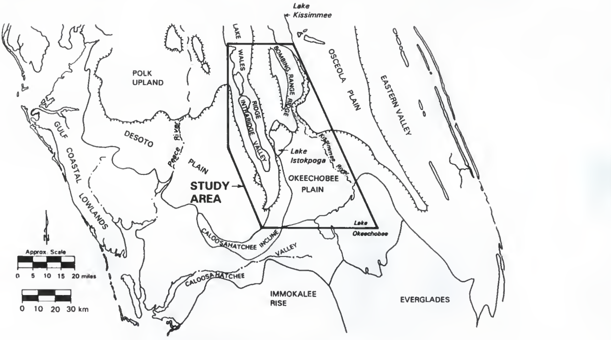


Figure 13. Geomorphic features in the study area (after White 1970).

Table 1. Marine terraces in Florida as identified by various geologists.

Terrace	Elevation	Age
	After MacNeil (1950)	
Okefenokee	46 m (150 ft)	Yarmouth
Wicomico	30.5 m (100 ft)	Sangamon
Pamlico	8-11 m (25-35 ft)	Wisconsin
Silver Bluff	2.4-3 m (8-10 ft)	Recent
	After Puri and Vernon (1964)	
Coharie	67 m (220 ft)	Aftonian Interglacial
Okefenokee	46 m (150 ft)	Yarmouth Interglacial
Wicomico	30.5 m (100 ft)	Sangamon Interglacial
Pamlico	9 m (30 ft)	Peorian Interglacial
Silver Bluff	2.4 m (8 ft)	Late Wisconsin Interstadial
	After Alt and Brooks (1965)	
	65.5-76 m (215-250 ft)	Upper Miocene
	27-30.5 m (90-100 ft)	Pliocene
Insignificant Stand	21-24 m (70-80 ft)	Pliocene or Pleistocene
Insignificant Stand	14-17 m (45-55 ft)	Pliocene or Pleistocene
	8-11 m (25-35 ft)	Pleistocene
	After Healy 1975	
Hazelhurst	65.5-97.5 m (215-320 ft)	Miocene or Pliocene
Coharie	52-65.5 m (170-215 ft)	Pleistocene
Sunniland and Okefenokee	30.5-52 m (100-170 ft)	Pleistocene
Wicomico	21-30.5 m (70-100 ft)	Pleistocene
Penholoway	13-21 m (42-70 ft)	Pleistocene
Talbot	8-13 m (25-42 ft)	Pleistocene
Pamlico	2.5-8 m (8-25 ft)	Pleistocene
Silver Bluff	<3-3 m (<1-10 ft)	Recent

Holocene in age, evidence for higher-than-present sea levels during the Holocene may be present in beach ridges on off-shore islands along Florida's west coast. Several researchers have argued that these represent a series of higher sea levels ranging from less than 1 m up to 3 m above present levels since about 5000 B.P. (e.g., Missimer 1973; Stapor and Tanner 1977; Stapor et al. 1991; Tanner 1991; Walker 1992; Walker et al. 1994).

Central Highlands. The Central Highlands comprises a series of localized high areas (ridges) separated by low-lying valleys. Both the ridges and the valleys tend to be linear in form and oriented roughly parallel to modern coastlines (White 1970:111-112). White (1970:113) suggests that the differences in elevation between ridges and valleys are the result of differential subsidence of the underlying limestone. He also suggests that this has occurred since Wicomico times, reasoning that if the Wicomico sea had inundated the highlands, ridge features that are at elevations lower than the Wicomico sea (i.e., less than 30 m) would have been destroyed (White 1970:113).

The Lake Wales Ridge represents a southward extension of the Central Highlands. It is a narrow finger of land that begins near the common corner of Polk, Osceola, Orange, and Lake counties and extends south for a distance of about 137 km (85 mi) ending a few miles north of Venus in Highlands County. The maximum elevation is approximately 91 m (300 ft) AMSL near the town of Lake Wales. The linear structure of the ridge appears to be the result of the deposition of coarse siliciclastics along a prograding delta that subsequently was straightened along its flanks by coastal erosion during Okefenokee times (White 1970:112-113, 120-123). A major feature is a chain of lakes that extends down the center of the ridge in what is known as the Intraridge Valley. This narrow, steep-walled lowland runs from the north shore of Lake Livingston near Frostproof south to Lake Placid. Most of these lakes were formed by solution of the underlying limestone which resulted in the formation of sinkholes (Bishop 1956:32; Cooke 1939:102; White 1970:120). According to White

(1970:119), the valley itself may be the result of reduction by solution of the underlying limestone along a structural lineament or fault.

The east side of the Lake Wales Ridge is a rather abrupt scarp that may have been the western shore of a large embayment that once occupied the Kissimmee River valley (White 1958:42-43). The east side of the Ridge is also characterized by a series of undulating dunes that are oriented at right angles to one another. The topography is very irregular with numerous hills separated by swales and depressions, some of which hold water. The most likely explanation for this topography is aeolian reworking of surface sands which formed ridges and blowouts (White 1958:39-41).

Osceola Plain. The Osceola Plain is a flat, marine terrace that is believed to have formed when sea level was 12 m or more above present levels (Lane et al. 1980). It attains a maximum elevation of about 24 m (80 ft) at its northern end where it rises towards the higher Orlando Ridge. The terrace slopes gradually to the south with an elevation of about 15 m (50 ft) along the shoreline of the next lower terrace (Lane et al. 1980). Bombing Range Ridge provides the only conspicuous topographic relief with an elevation of 38-44 m (125-145 ft). It forms the divide between the Kissimmee River to the east and Arbuckle Creek to the west. White (1970:138) considers Bombing Range Ridge to be a relict marine sand bar that was created during the preceding Okefenokee high stand.

Okeechobee Plain. The Okeechobee Plain is a broad, flat terrace that contains the southern part of the Kissimmee River, all of Lake Okeechobee, and a large part of the Everglades. It formed during the advance of the Pamlico sea during the late Pleistocene (Brooks 1974). At the toe of the scarp that forms the boundary between the Okeechobee and Osceola Plains, the elevation ranges between 9 and 12 m (30-40 ft). The terrain slopes very gradually to the south reaching elevations of only 6 m (20 ft) above mean sea level at the north end of Lake Okeechobee (White 1970:142). Cooke (1939:101-102) believed that the Lake Okeechobee basin originated as a slight depression in the Pamlico sea He felt that Lake Istokpoga and Lake Kissimmee, as well as other lakes in the Kissimmee basin, all originated as similar types of depressions. However, if he is correct, then they must be older than Lake Okeechobee because they lie on higher and older marine terraces.

Polk Upland. The Polk Upland is a mature terrace that has been dissected by several well-defined drainage systems. The Pleistocene sediments that cover it were deposited during the Okefenokee marine transgression (Clark 1972:29; Healy 1975). According to White (1970:133), the southern scarp of the Polk Upland is the result of a marine standstill during Wicomico times which eroded the earlier Okefenokee terrace.

DeSoto Plain. The DeSoto Plain is a submarine terrace that developed during a standstill in the Wicomico transgression (White 1970:141). It is extremely flat with an elevation difference of only about 4.5-7.6 m (15-25 ft) from north to south (White 1970:140). The Peace River is fairly deeply entrenched into this feature, particularly at its northern end. The DeSoto Plain also contains the headwaters of Fisheating Creek.

Caloosahatchee Incline. The Caloosahatchee Incline is a long, narrow, sloping surface that borders the east flank of the Lake Wales Ridge and the southern edge of the DeSoto Plain. It is regarded by White (1970:141) to have been deposited at the down-current end of a submarine shoal. However, Clark (1972:31) believes that this feature represents an erosional marine shoreline that developed during a standstill at about 18 m (60 ft), although he is not certain if this occurred during a temporary pause in the regression of the Wicomico sea, or during a similar pause in the advance of the succeeding Pamlico sea.

Environment

Environmentally, it is possible to divide the study area into three major zones: the higher, more rolling Central Lakes District separates the low lying Eastern and Western Flatlands (Brooks 1982; cf. Davis 1973).

Central Lakes District. The Central Lakes District includes the Lake Wales Ridge. It is characterized by rolling hills of well-drained sand interspersed with lakes and ponds. The prevailing vegetation is sand pine, longleaf pine, turkey oak, and scrub live oak (Abrahamson et al. 1984; Carter et al. 1989; Davis 1943:156-160; Ford et al. 1990; Harper 1921:124, 1927:82). Pine flatwoods or scrubby flatwoods are present in areas of lower elevation and poorer drainage (Abrahamson et al. 1984; Carter et al. 1989; Ford et al. 1990; Harper 1921:124). Hardwood hammocks are sometimes found along creeks and streams or along lakeshores.

Lakes are numerous and of varying types. Some are shallow basins that hold water seasonally while others are larger, deeper, and contain water year-round. On the Lake Wales Ridge, major lakes include Reedy Lake, Lake Livingston, Lake Jackson, Lake Josephine, Lake June-in-Winter, and Lake Placid. The elevation of the potentiometric surface of the Floridan Aquifer in this area averages 18-27 m (60-90 ft) above sea level with the gradient to the south (Tibbals 1990:Figure 21; Yobbi 1983). Most of these lakes lie at elevations that are above the potentiometric surface; thus there is no upward leakage of water into the lakes from the artesian aquifer and the water levels are primarily rainfall dependent (Adams and Stoker 1985; Belles and Martin 1984; Hammett 1981; Stewart 1966:72-76). Downward leakage does occur, however, and the ridge serves as a major recharge area to both the artesian (Floridan) and non-artesian aquifers (Tibbals 1990).

Freshwater seeps are common along the flanks of the ridge as a result of the lateral movement of ground water from areas of higher to lower elevation (Bishop 1956:47-48; Carter et al. 1989:12). These seeps emerge to contribute to the large swamp systems that are present on either side of the ridge -- Lake Istokpoga and its associated outflow to the east, and Little Charley Bowlegs and Fisheating Creeks to the west. The seeps are characterized by the presence of distinctive "cutthroat grass" vegetation, and so are known locally as "cutthroat seeps" (Carter et al. 1989:12, Harper 1921:208, 1927:160-161).

Development is encroaching on the area today. The northern Kissimmee region lies to the south of the rapidly expanding Orlando/Disney World urban, residential, and entertainment complex. Farther south, near Sebring, the many large lakes attract tourists and seasonal residents who enjoy boating and fishing. Those areas that remain undeveloped contain citrus groves.

Eastern Flatlands. The large expanse of relatively flat terrain and somewhat-poorly to poorly drained soils located to the east of the Lake Wales Ridge is known as the Eastern Flatlands. It encompasses most of the northern and central Kissimmee regions and all of the southern region. Harper (1921:136, 137-138) described the area as "... for the most part monotonously level...Near the lake region the topography is often a little undulating, and the transition from one region to the other is gradual, though there are also places where it is abrupt. Shallow depressions abound, ranging in size from lakes covering several square miles (most of these near the lake region) to small wet prairies and cypress ponds. Streams are few and sluggish, and the rivers have extremely shallow valleys."

The principal lakes in the northern portion of this region include Lake Tohopekaliga, East Lake Tohopekaliga, Alligator Lake, Lake Hatchinea, and Cypress Lake. These are part of the chain of lakes that form the headwaters of the Kissimmee River (Lichtler 1972:8; Parker et al. 1955:302; USA COE 1991:A-4). Reedy Creek is a major waterway that drains the Central Highlands and provides outflow to this lake system. Major surface-water features in the central Kissimmee region include Lake Kissimmee, Lake Weohyakapka, Lake Arbuckle, Lake Istokpoga, the Kissimmee River, and Arbuckle Creek.

Vegetation consists primarily of pine and saw palmetto flatwoods interspersed with grassy ponds and cypress heads. Small knolls and ridges of moderately well-drained soil support pine and scrub oak vegetation. The largest and most prominent of these scrubby ridges is Bombing Range Ridge, described above. Hardwood hammocks are common along the river and major streams, and around some of the larger lakes.

A unique ecological feature of the area is the treeless, palmetto prairie which is especially common along the Kissimmee River south of Lake Kissimmee (Harper 1921:203-204, 1927:87-88, 163). Davis (1943:28) relates that the origin of these dry prairies is believed by some to have been caused by numerous fires set by settlers and earlier by Indians. Davis doubts this because the earliest accounts of the region refer to these prairies as natural communities extending over the same amount of area as they presently occupy. Instead, he suggests that the absence of trees is due to the fluctuating water table which favors vegetation, such as grasses and low bushes, with shallow root systems (Davis 1943:128).

Two major water features dominate the central portion of the Eastern Flatlands: the Kissimmee River and Lake Istokpoga. In its natural state, the Kissimmee was originally a slow-moving, meandering river with a floodplain that varied from 1.5-3 km in width (FDNR 1974:89; USA COE 1991:7). Much of this floodplain consisted of pickerelweed flag marsh, maidencane flag marsh, and beakrush marsh (Kushlan 1990:344-345; USA COE 1991:9, Table 1). Runoff from the surrounding poorly drained flatlands, and the rise of lake levels in the upper basin at the end of the summer rainy season, caused the river regularly to overflow its banks. Indeed, early accounts of the region's natural environment are nearly unanimous in commenting on the overwhelming presence of water throughout the valley (e.g., Davis 1943:34; Hancock 1979:19; McCaffrey et al. 1976; Parker et al. 1955:301-302; Will 1977:9-10). In some years the flooding was so severe that the river resembled a wide lake, and low-lying areas were often under water for several months at a time (USA COE 1991:15, A-6). As a result, the river has experienced numerous attempts to control it (cf. McCaffrey et al. 1976; Tebeau 1974; VanArman et al. 1984:138-139). The most recent, in the 1960s, was a massive flood-control project by the U.S. Army Corps of Engineers which involved channelizing the river and constructing a series of levees and water-control structures along its course. While successful in controlling flood waters, the negative effect of this project on the natural ecosystem has been dramatic. Seasonally fluctuating water levels in conjunction with undulating floodplain topography, a meandering river channel, oxbows, and natural, discontinuous levees, were essential components for maintaining the river's diverse mosaic of natural wetland habitats. By eliminating seasonal inundation, channelization has caused many marshes to dry up allowing terrestrial vegetation to invade (VanArman et al. 1984:154). Of an estimated 14,000 hectares of wetlands that once existed in the floodplain, only about 5,700 remain today (USA COE 1991:26). Most of the drained land is used for cattle ranching.

Lake Istokpoga is the fifth largest lake in Florida. It is fed by Arbuckle Creek, which enters the lake from the north. The lake occupies a natural depression that intersects the water table so ground water moving down-gradient from the higher Lake Wales Ridge, located to the west, provides base flow to the lake (Kohout and Meyer 1959:15, 17-25). At one time a large, wet savannah existed to the south of the lake. Known as Indian Prairie, it channeled sheet flow from the lake south towards Lake Okeechobee (Kohout and Meyer 1959:13; Parker et al. 1955:311). According to early accounts, this broad expanse of herbaceous grasses and cabbage palm hammocks rivaled the Everglades in its beauty and abundance of wildlife (Davis 1943:49; Harper 1927:100-103, 166; Small 1921:57). Harper (1927:166), for example, described Indian Prairie as "a region of beautiful palm savannahs, covering apparently a few hundred square miles...the abundance of palmettoes and tall grass are a wonderful sight, hardly matched anywhere else in the United States." Unfortunately, flood-control measures and drainage canals have essentially destroyed this wetland. Today most of the area formerly occupied by Indian Prairie is used for agriculture. It also contains significant deposits of peat (Davis 1946:129-132).

The southern portion of the Eastern Flatlands extends into the marsh and savannah environment that characterizes the Lake Okeechobee basin. Poorly drained pine flatwoods are present in the upland portions of this subarea with hardwood hammocks along rivers and creeks, and on natural levees around the lake margin (Carter et al. 1989; VanArman 1984:140-141). Historic drainage practices and the construction of massive dikes and levees have altered drastically the size and extent of Lake Okeechobee and the Everglades (VanArman et al. 1984:156). Much of the wet savannah environment that is so often associated with this part of the state is now used for cattle ranching and agriculture, and exotic vegetation has invaded many formerly natural areas (Alexander and Crook 1974). The Kissimmee River is the primary source of water for Lake Okeechobee; however, several other drainages flow into the lake including Fisheating Creek, Taylor Creek, Lemkin Creek, and Nubbin Slough.

Western Flatlands. The Western Flatlands include the lowlying area west of the Lake Wales Ridge that is drained by Charley Bowlegs Creek, Fisheating Creek, and the Peace River. Other important drainages include Payne Creek and Horse Creek. The lack of topographic relief contributes to the poor drainage of the region. The result is numerous swamps, marshes, and bayheads. The dominant vegetation is pine and palmetto flatwoods (Davis 1943:47-48; Robbins et al. 1984).

Regional Hydrology

The availability of surface water and associated wetland habitats in south Florida is the result of a complex interaction between precipitation, runoff (including both surface runoff and base flow), the position of the non-artesian (water-table) and artesian (Floridan) aquifers, and evapotranspiration (i.e., water lost to the atmosphere directly through evaporation and indirectly through transpiration via plants). Sea level has an indirect effect in that advances and retreats of the sea affect the position of the potentiometric surface of the artesian aquifer. Figure 14 depicts these hydrologic relationships within the study area.

Precipitation. Variability in precipitation occurs at both the short- and long-term temporal scales. While daily weather is somewhat random, with rainfall varying from place to place and day to day, seasonal patterns of wet and dry periods are observable. These seasonal variations are often dramatic, as discussed in the section on climate, and can affect the availability of surface water (Cooke 1939:102; Flippo and Joyner 1968; Parker et al. 1955, Pride and Crooks 1962), the types of vegetation that occur (Davis 1943:33-35, Kushlan 1990:346-349), and the range, distribution, and sizes of various kinds of wildlife, particularly waterfowl and fish (Cox et al. 1976; Dineen 1974; Kushlan 1990:349-356).

At the long-term temporal scale, variation in rainfall appears to be cyclical, although this is difficult to monitor because of the relative lack of data over an extended period. Pride and Crooks (1962:Figure 2) present rainfall data for the entire state beginning in 1881 and extending to 1960. Their data show periods of above-average rainfall alternating with periods of lower than average rainfall at intervals of from 5 to 20 years. Rainfall records for east-central and south Florida extending back to 1867 (Tibbals 1990:E7, Figure 6) indicate a slightly different pattern. A general increase in precipitation is indicated between 1870 and 1888, followed by an extended period of decline between 1888 and 1931. Precipitation increased gradually during the 1930s-1950s before drought conditions reoccurred beginning in the early 1960s. Rainfall increased gradually during the 1970s and then another drought occurred during the early 1980s.

Coleman (1982) postulated a relationship between rainfall patterns and temperature based on data gathered between 1925 and 1978. Analysis of these data indicated that lower temperatures generally have resulted in a decrease in winter precipitation and extended drought conditions in south Florida because of a reduction in cyclonic activity. The data also indicated that the peak annual precipitation during the period under study corresponded with peak mean annual temperatures suggesting a possible linkage.

Surface water. Studies to determine the effect of reduced precipitation on surface water in central and south Florida have consistently demonstrated that a reduction in precipitation has a direct effect on stream flow and lake levels (Coleman 1980; Flippo and Joyner 1968; Freiberger 1972; Hughes 1974; Kohout and Meyer 1959; Pride and Crooks 1962). Many of the streams in the study area (e.g., Fisheating Creek, Taylor Creek) cease to flow during even short periods of drought (Lichtler 1972:5,

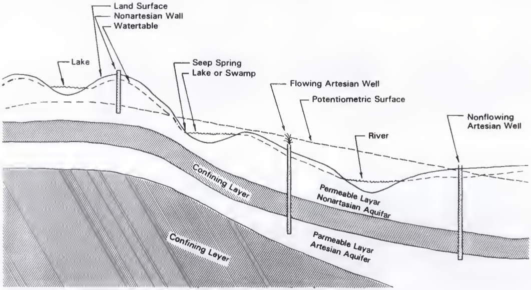


Figure 14 Hydrological relationships in the study area (modified from Parker et al. 1955:Figure 30).

17, Parker et al. 1955:315, 319) because their beds are not incised deep enough to intercept the water table. Thus, there is no ground-water seepage to maintain base flow during periods of low rainfall. The flow of the Kissimmee River also declines during dry periods (Coleman 1980; Pride and Crooks 1962:12); however, it is better able to maintain its flow because its channel is deeply incised, particularly at its northern end, and so its base flow is maintained by the substantial discharge it receives from the surrounding uplands (Parker et al. 1955:524-550). This was even more true of conditions prior to the 1880s than it is today because channelization projects have changed the flow regime of the river from one of slow surface runoff and substantial base flow to one of rapid surface runoff and reduced base flow (USA COE 1991:25).

Water levels in lakes that are not recharged by artesian springs also are affected by drought conditions. Recharge to surface-water lakes occurs directly from precipitation as well as from ground-water seepage in those lakes which have basins that intercept the water table. During dry periods, both of these water sources diminish. Recharge via upward leakage from the artesian aquifer is limited because the lakes lie at elevations above the potentiometric surface, or because they are separated from the Floridan by a relatively impermeable confining layer. Lake water is lost primarily through evaporation, and for those lakes that lie above the potentiometric surface, by vertical seepage through underlying sediments (Hammett 1981). This last process is an especially important one on the Lake Wales Ridge where many of the lake bottoms consist of, and are underlain by, permeable sands and silts (Bishop 1956:48, Belles and Martin 1985). Some of this vertical leakage replenishes the ground-water supply and contributes to base flow in the low-lying areas, enabling these water sources to persist for a time despite an absence of rainfall. During extended drought conditions, however, even base flow will eventually cease.

Non-artesian aquifer. Rainfall also is the principal source of recharge to the water-table, or non-artesian, aquifer. Hydrographs developed from well data along the Lake Wales Ridge in Highlands

County show a correlation between water-table fluctuation and variation in rainfall (Bishop 1956:38). The water table is most responsive to rainfall when it is relatively close to the surface. When the water table is a considerable distance below the ground surface, during extended dry periods, for example, the response may lag behind the precipitation event by a month or more (Lichtler 1972:20). Brief showers during a dry period may have little effect on the water table because the water is held as soil moisture or is returned to the atmosphere via evapotranspiration.

Since the non-artesian aquifer is unconfined, water moves from areas of higher elevation to areas of lower elevation, with the direction of flow generally following the contours of the land (Bishop 1956:37; Conover et al. 1984.39-40). Rainfall falling on high areas, such as the Lake Wales Ridge, will move down-gradient into lake basins on the ridge, and into lakes and rivers in the low-lying valleys on either side of the ridge (Figure 14). Variation in the position of the non-artesian aquifer, therefore, affects those surface-water bodies that intercept the water table and are recharged by it.

Artesian aquifer. The artesian aquifer is water contained in rock or sediments that are separated from overlying sediments by a confining bed, usually consisting of clay. The water in the aquifer is under pressure because the confining unit prevents or inhibits upward movement. When the artesian aquifer is penetrated by a tightly cased well, the level to which the water rises is known as the potentiometric surface (Fetter 1988:102). Florida's principal artesian aquifer system is known as the Floridan and its base level is the sea. At the long-term temporal scale, changes in the level of the sea affect the level of the potentiometric surface. The effect of sea level on the position of the Floridan aquifer can be seen most directly today along the coast where water levels in wells that penetrate the Floridan are highest during periods of high tide and lowest during periods of low tide (e.g., Boggess 1974:14-17).

The major source of recharge to the Floridan, and so the major source of short-term variability in the potentiometric surface, is rainfall. Within the study area, the major recharge area is the Lake Wales Ridge. Most water that is not lost to evapotranspiration percolates downward through the permeable sands that cover the ridge. Some of this water is lost to the non-artesian, or water-table, aquifer, some moves laterally to be discharged in seep springs and lakes, and the rest recharges the Floridan. Surface runoff is minimal because the surface sands are highly permeable. Studies conducted by the Soil Conservation Service indicate that rainfall would have to occur at a rate of over 200 cm (80 in) per hour to cause any appreciable surface runoff on the ridge (Bisbop 1956:38). In contrast, the low-lying Kissimmee River basin essentially is an area of discharge. This is because the potentiometric surface is at or above the ground surface in this area (Kohout and Meyer 1959; Parker et al. 1955:158-160; Tibbals 1990:E28, E29).

Shaw and Trost (1984:106-120) compared water levels in wells penetrating the Floridan aquifer within the Kissimmee River basin with rainfall amounts for a two-year period (1980-1981). They found that ground-water levels fluctuated by as much as 1.5 m (5 ft) during some periods of low rainfall. In general, the levels were higher in September than in May, reflecting seasonal variation (Shaw and Trost 1984:106). Annual fluctuations of .6-1.2 m (2-4 ft) were observed in western Orange and Osceola Counties, and between .5-1.5 m (2-5 ft) in central Polk County, south of Lake Kissimmee. These areas are close to the Lake Wales Ridge and so were probably affected by variation in recharge originating on this topographic high.

Sbaw and Trost (1984) also examined over forty years of well and rainfall data for the region in order to evaluate long-term fluctuations in the level of the Floridan. They noted a general downward trend, with water levels in some wells dropping by as much as 4.6 m (15 ft) (Shaw and Trost 1984:109). While they attributed the decline to increased pumping, they noted that water levels in the Floridan still fluctuated in response to rainfall. In years of higher-than-average rainfall, the water levels also were higher, while in years of lower-than-average rainfall the water levels dropped (Shaw and Trost 109-114).

Johnston et al. (1980) attempted to reconstruct the potentiometric surface of Florida prior to development (ca. 1930s). Their model indicated that the general configuration of the predevelopment potentiometric surface was consistent with the area of greatest recharge near the Green Swamp region in central Florida, with a gradient to the south-southeast. However, shifts in the potentiometric contour lines along the Lake Wales Ridge have apparently occurred in recent times which indicate that there has been a change of hydraulic head values by as much as 3 m (10 ft) since the 1930s, presumably as a result of development (see also Tibbals 1990:E22, Figures 20 and 21).

The effect of pumping on the position of the potentiometric surface is important since these data can serve as an analog for the effect of sea level on the position of the Floridan aquifer, and in turn, the effect of a lowered artesian aquifer on non-artesian and surface-water hydrology in Florida's interior. With a reduction in sea level, the position of the potentiometric surface would be lower, and this, in turn, would affect rates of recharge and discharge in the central interior.

Although the lakes on the Lake Wales Ridge are primarily rainfall dependent, these sand-filled sinkholes have a direct hydraulic connection to the artesian aquifer which enables downward leakage to occur (Kohout and Meyer 1959:55-65; Hammett 1981). A decline in the potentiometric surface increases the potential for downward leakage into the Floridan by increasing the downward gradient (Kohout and Meyer 1959:65; Tibbals 1990:E78). An increase in downward leakage affects lake levels and makes less water available to the non-artesian aquifer.

Between September 1970 and December 1972, the lake level in Lake Jackson near Sebring declined by about 1 m (3 ft) (Hammett 1981). Hammett concluded that a drop in precipitation was responsible for only a part of this decline. His examination of well data indicated that there had been a concomitant drop in the potentiometric surface of about 3-6 m (10-20 ft) between 1951 and the mid-1970s resulting in an increase in downward leakage which also affected the water levels in the lake. While the recorded drop in the potentiometric surface was due to increased pumping and channelization, the implications for paleoenvironmental reconstruction are clear. With a drop in sea level, the potentiometric surface of the Floridan Aquifer also would have dropped, increasing downward leakage and reducing lake levels.

In high discharge areas, the reduction in the potentiometric surface would tend to capture some of the water that would have ordinarily been leaked upward to be discharged into the water table (Tibbals 1990:E78). This would reduce base flow in deeply incised streams like the Kissimmee River, and in lakes whose basins intercept the water table such as Lake Istokpoga.

Evapotranspiration

The total surface- and ground-water flow of a region is equal to the difference between rainfall and evapotranspiration (Visher and Hughes 1969). A decrease in rainfall would be accompanied by a relative decrease in cloud cover and humidity resulting in an increase in air temperature, conditions that tend to increase the potential for evaporation (cf. Cox et al. 1976:2-39). If evapotranspiration exceeds precipitation, a water deficit is likely. Based on actual evapotranspiration rates, Dohrenwend (1977) calculated the water surplus of various regions of the state. The area encompassing Lake Okeechobee and extending to the west-northwest (including the Lake Wales Ridge, Peace River valley, and Fisheating Creek) was found to have a smaller surplus than any other area of the state (Dohrenwend 1977:190). He concluded that under conditions of reduced rainfall, this area would rapidly develop a water deficit and so be vulnerable to droughts. Part of the reason for this is the large amount of free water surface that is present in the region compared to other parts of the state where vegetation cover is greater

Paleoenvironmental Conditions

Periodic fluctuations in climate and precipitation no doubt had an effect on the adaptive strategies of the people who occupied south Florida prehistorically at both the long- and short-term temporal scales. Perhaps the most important factor influencing prehistoric settlement patterns was the differential availability of water and wetland habitats. For example, the arid conditions and lack of surface water that characterized the late Pleistocene and early Holocene have long been considered important determinants of Paleoindian and early Archaic period settlement patterns (Dunbar 1981; Dunbar and Waller 1983; Neill 1964). Conversely, the emergence of modern wetland habitats in interior south Florida at approximately 3500 B.P. appears to have been closely correlated with the development of a more sedentary lifestyle (Austin 1996a; Mitchell 1996; Russo 1986; Sigler-Eisenberg 1985, 1988). The relevance of this to the present study lies in the reduced access to lithic raw materials located farther north as native peoples in south Florida became less mobile.

Late Pleistocene-Early Holocene Environment

Carbone (1983:3-4) has emphasized the unique nature of Florida's environment between 18,000 and 10,000 B.P. indicating that there is no modern analog for what was present at that time. The climate was dry, windy, and cool (Kutzbach and Wright 1985:178-180; Wright 1981:121, 123) and seasonal differences were less pronounced. Gates (1976) has estimated that the average summer temperature was about 8-10 degrees centigrade cooler than today; however, winter temperatures were probably milder than they are today based on the presence of animals such as the giant land tortoise, Geochelone crassiscutata, an extinct species whose modern descendants do not tolerate freezing temperatures (Science Applications, Inc. 1981:1-81).

Environmentally, south Florida apparently was quite different from north Florida during this time (Delcourt 1983; Watts and Hansen 1988). Instead of the closed pine forests that characterized north Florida, south Florida was very open, with large expanses of herbaceous prairie. Sand dunes were covered with xeric herbs and shrubs, such as rosemary and sandhill polygonella, intermixed with scrub oak. Watts and Hansen (1988:320-321) suggest that south Florida may have been a relatively isolated biotic province with its own unique vegetation and climate.

Not surprisingly, this late Pleistocene vegetative complex was inhabited by a faunal population that was adapted to this unique habitat. According to Webb (Science Applications, Inc. 1981), the predominant vertebrate species included large grazing animals such as horses, camels, mammoths, bison, ground sloths, and giant land tortoises, and browsing animals such as mastodons, tapirs, and peccaries. These animals suggest the presence of large expanses of grassland. Although not abundant, aquatic species such as alligators, turtles, and fish also were present indicating that, despite the generally arid conditions, some streams and water bodies did exist, particularly along the coast.

At about 13,500 years ago, the climate warmed and rainfall became more abundant, although it was still cooler and drier than today (Watts 1975, 1980; Watts and Hansen 1988:Table 4; Wright 1971). Data from Lake Tulane near Avon Park (Watts and Hansen 1988:315, Figure 2) indicate a dominance of pine, suggesting more mesic conditions. However, most lakes in the region remained dry (cf. Watts 1969, 1971, 1975). Extremely arid conditions returned by about 11,000 B.P. and continued until about 8500 B.P. (Watts and Hansen 1988:311-313). At Lake Tulane, large amounts of charcoal are present in sediments dating between about 11,000-7000 B.P. indicating a prevalence of fires which suggests that an abundance of dry fuel was present (Watts and Hansen 1988:311). The inference is that precipitation was minimal during this time. This is supported by the absence of organic sedimentation at other lakes in southern Georgia and northern and central Florida (e.g., Lake Louise, Mud Lake, and Buck Lake, the latter near Lake Annie in Highlands County) prior to 8500 B.P. (Watts 1969, 1971, 1975; Watts and Hansen 1988:311-313). In effect these lakes were dry basins.

This pattern is repeated at Little Salt Springs and Warm Mineral Springs. Clausen et al. (1979:610-611) report no aquatic or marsh plants in pollen dated to 9920 B.P. at Little Salt Springs and dry conditions also are indicated at Warm Mineral Springs between 9870-8520 B.P. (Clausen et al. 1975:197). However, at Windover, the basal peat stratum was radiocarbon dated at 10,750-10,160 B.P. and contained the remains of water lilies (Doran and Dickel 1988a:Table 2). Apparently, this pond contained water on a relatively consistent basis until the present, although water levels varied dramatically. A "rubber peat" stratum overlying the basal water lily peat contained an abundance of oak pollen and a decrease in pine pollen. It began forming around 9500-9000 B.P. and terminated at about 8500-8000 B.P. and water levels are believed to have been about 1-2 m deep, partially as a result of salt-water intrusion (Doran and Dickel 1988a:283).

Watts (1975:686-687) suggests three possibilities for the xeric conditions at this time: 1) an absolute absence of rainfall, 2) critical variations in the seasonal distribution of rainfall, or 3) excessively rapid loss of water in permeable sands due to a depressed water table. Given the earlier discussion of regional hydrology, it is likely that a combination of these factors contributed to the xeric character of south Florida's early Holocene environment. Sea levels were at their lowest at about 18,000 B.P.; but exactly how low has not been determined precisely. Original estimates indicated that sea levels may have been as much as 130-100 m lower than at present (Cronin 1983:Figure 1; Emery and Garrison 1967; Milliman and Emery 1968), although Dillon and Oldale (1978) indicate that they may have been no more than 80-85 m lower. The most conservative estimates are those by Blackwelder et al. (1979) who suggest that sea levels were only 57 m lower than present at 18,000 B.P. The reasons for the differences in these estimates are summarized by Science Applications, Inc. (1981:143-152). They include: 1) the selection of appropriate sea-level indicators, 2) the tendency of the indicators to be transported from their original depositional environment, 3) the reliability of the dating techniques employed, 4) the relatively limited number of dates for sea levels older than 12,000 B.P., 5) the inability of the limited number of reliable indicators to accurately identify sea-level fluctuations. In addition, the early estimates of Milliman and Emery utilized sea-level data from locations north of Cape Hatteras, an area that Dillon and Oldale (1978) later showed to have been affected by isostatic downwarping. In contrast, the southern continental shelf, including Florida, appears to have been relatively stable since the late Miocene (Scholl et al. 1969). The main differences that these revised estimates would have for paleoenvironmental reconstruction are: 1) a slightly reduced land mass than was previously believed, and 2) a less rapid rate of sea-level rise than was envisioned using the Milliman and Emery estimate.

In a recent review of late Quaternary sea-level rise, Cronin (1983:188) argues that the varying estimates of sea level during the late Pleistocene glacial maximum at ca. 18,000 B.P. indicate that the correct interpretation may be that many sea-level positions occurred depending on local conditions. The presence of many submerged terraces suggests that short-term fluctuations in sea level probably also occurred. The situation is complicated by the fact that few localities have been mapped adequately and few reliable dates are available.

Regardless of which estimate is correct, the potentiometric surface of the Floridan aquifer would have been much lower. For example, water levels in Little Salt Springs are estimated to have been 26 m lower than present at about 13,500 B.P. (Clausen et al. 1979:613) and 10-13 m lower than present at Warm Mineral Springs at 10,000-9,000 B.P. (Clausen et al. 1975). Such a depressed potentiometric surface would have contributed to rapid vertical leakage of any water that collected in upland lake basins, such as those on the Lake Wales Ridge. Furthermore, lower sea levels would have exposed a larger land mass, insulating the interior of the peninsula from off-shore breezes carrying moisture and cloud cover. The absence of large surface-water features such as Lake Okeechobee and the Everglades would have reduced the amount of moisture entering the atmosphere via evaporation, contributing to reduced precipitation and arid conditions.

A reduction in rainfall would have affected the position of the water-table aquifer, diminishing base flow and recharge to lakes and streams that intercepted it. In low-lying areas, shallow streams and perched lakes would have dried up as precipitation, runoff, and base flow dwindled. With a depressed artesian aquifer, upward leakage would have been non-existent. The only sources of permanent water would have been sinkholes in low-lying areas (such as Warm Mineral and Little Salt Springs) that were of sufficient depth to have breached the Floridan aquifer. Only one major spring, Kissengen Spring in central Polk County, is located within the study area, and no major artesian springs have been recorded in the Kissimmee River and Lake Okeechobee basins (cf. Ferguson et al. 1947; Parker et al. 1955; Rosenau et al 1977).

With the retreat of the continental ice sheets, their effect on Florida's climate lessened and seasonal radiation extremes became larger. After 9000 B.P. summers tended to be warmer and winters cooler than today (Kutzbach and Guetter 1986). Precipitation also increased as evidenced by widespread organic sedimentation in most of the lakes in the region indicating that water was being held in the lake basins on a relatively permanent basis. A relatively mesic environment is indicated for the immediate vicinity around Warm Mineral Springs during the early Holocene, or ca. 9000-8000 B.P. (Cockrell et al. 1975; Sheldon and Cameron 1976). These data are corroborated by palynological data from Little Salt Springs where organic deposition did not begin until about 8500 B.P. (Brown and Cohen 1981, 1985; Clausen et al. 1979:611). This corresponds to Watts's data from interior upland lakes where organic sediments dated at 8500-8000 B.P. overlie organically sterile sands.

Widmer (1988:156-157) has suggested that the pollen data reflect the presence of regional vegetation zones in south Florida at this time. The data from lowland sinkholes seem to indicate mesic oases within an otherwise arid landscape, an interpretation that helps to explain the occurrence of archaeological sites in association with these water features. In the Central Highlands, the pollen data document that schlerophylous oak was the dominant vegetation indicating a more closed, scrub or dry forest environment and no pine. Prairie-like openings in the forest were present as indicated by pollen from various grasses and herbs (Watts 1975:676-677, 1980:400). Finally, the low-lying area that today contains the Everglades and Lake Okeechobee was probably a dry, karst plain since there is no evidence for peat accumulation there before 6000-5000 B.P. (Gleason et al. 1974:301; McDowell et al. 1969)

Pollen data from Little Salt Springs (Brown and Cohen 1985) suggest a shallow-water environment between 7000-5200 B.P.; however, evidence for fire is apparent in the earliest deposits suggesting more arid conditions (Brown and Cohen 1981), a pattern similar to Watts's studies where charcoal was most abundant in deposits that are suspected to have been drier than today. This shallow-water habitat eventually was succeeded by a woody-dominated plant community and eventually a modern bayhead forest as water levels deepened. A similar situation occurred at Windover where two reddish-brown peat strata were deposited between 8500-8000 B.P. and 6000 B.P.. These strata are interpreted as representing a shallow-water environment with water levels no more than 20 cm deep at a maximum (Doran and Dickel 1988a:283-284). After 6000 B.P., a more modern sawgrass environment prevailed.

Late Holocene Environment and the Origin of Modern Wetland Habitats

The trend toward the establishment of modern wetland habitats in south Florida probably began sometime around 6000-5000 B.P. This corresponds to the period referred to variously as the Holocene "climatic optimum" or Hypsithermal (Deevey and Flint 1957; Emiliani 1972; Gribbin and Lamb 1978:69) when temperatures were warmer than present. Using geological data and associated radiocarbon dates, Gleason et al. (1974:311) and Brooks (1974) infer that south Florida was extremely arid prior to 5000 B.P. and that the Kissimmee River may not have flowed. The deposition of calcitic mud in depressions within the Lake Okeechobee basin at around 6400 B.P., and the subsequent formation of peat deposits in the Everglades beginning around 5000 B.P., are believed to have occurred as a result of increased precipitation and runoff during a period of warm, moist climate (Brooks 1974:266; Gleason et al. 1974:310; McDowell et al. 1969).

Sea level also was higher during this time, although estimates of how high vary among researchers. Fairbridge (1961, 1974) has estimated that it was 3-4 m higher than present and Stapor and Tanner (1977) suggest a mid-Holocene high of 1.5 m above present levels. Scholl et al (1969:Figure 2) offer a more conservative estimate of 4 m below present levels, a figure that Widmer (1988:Tables 12 and 14) seems to accept as reasonable for southwest Florida. According to Widmer

(1988:165) this would have been sufficient "to raise the water table high enough to provide both the discharge of water from springs and the storage of surface water in lakes." Widmer's use of the term "water table" undoubtedly is meant to refer to the potentiometric surface of the artesian aquifer, not the water-table or non-artesian aquifer which, by definition, is separated from the artesian aquifer by a confining layer. While his conclusion may have been true for areas where artesian springs are located, it is doubtful that a sea-level rise to within 4 m of present-day levels would have affected water sources in the Kissimmee River and Lake Okeechobee basins since these are primarily influenced by precipitation and base flow rather than discharge from artesian springs. However, the higher potentiometric surface would have inhibited downward leakage from surface-water features thereby increasing their storage capacities, as well as the potential for base flow and surface runoff. This, in turn, would have contributed to the formation of the modern Kissimmee River and Lake Okeechobee. The creation of Lake Okeechobee also would have provided a large mass of surface water which would have contributed to evaporation and the potential for convectional thunderstorms.

At Lake Annie, near the southern terminus of the Lake Wales Ridge, Watts (1975:345) reported that pine dominates the pollen assemblage at 4715 B.P., and at 2630 B.P. bald cypress increases in abundance indicating an expansion of cypress swamps. At Little Salt Spring, in Sarasota County, analysis of peat deposits indicates that a wetter climate began to appear at about 5200 B.P., reaching its maximum at about 3200 B.P. (Brown and Cohen 1985:21-31). Gleason et al. (1974:311) also indicate that precipitation in south Florida gradually increased after about 2900 B.P.

By about 3000-2500 B.P., modern environmental conditions existed in south Florida. While no major changes appear to have occurred since that time, periodic, short-term fluctuations in climate, precipitation, and sea level have affected the hydrology and ecology of the region. These periodic fluctuations are observable as early as the mid-Holocene For example, Denton and Karlen (1973) document cyclical periods of glacial expansion and contraction with expansion intervals lasting up to

900 years and contraction intervals lasting approximately 1750 years Major glacial advances occurred at 3300-2400 B.P. and during the Little Ice Age, beginning at ca. A.D. 1500. Major recessions occurred at 6175-5975 B.P., 4030-3300 B.P., 2400-1250 B.P., and 1050-460 B.P. Denton and Karlen (1973) suggest that cyclical variation in solar activity could be the cause of climatic, and hence glacial, fluctuations. Fairbridge and Hillaire-Marcel (1977) and Magny (1992) have made similar claims for the effect of solar activity on world-wide climate. Kukla (1969:315-316) documents several periods of alternating warmer and cooler climates during the middle to late Holocene. Warm intervals occurred from 4000-3450 B.P., 2700-2100 B.P., and 1600-750 B.P. while cooler climates prevailed between 4600-4000 B.P., 3450-2700 B.P., 2100-1600 B.P., and 750-60 B.P. In general, his data correspond reasonably well with Denton and Karlen's data for glacial expansion and retraction.

While the general trend throughout the Holocene appears to have been one of increasing precipitation, climatic fluctuations resulted in conditions that were both wetter and drier than today. For example, Gleason et al. (1974:311) report evidence of ancient fires in a peat bog in Marion County, and from this infer four separate periods of severe drought between 4030 and 2900 B.P. During these periods it is reasonable to infer that the flow of water in the Kissimmee River would have been reduced, perhaps substantially, while shallow streams and lakes may have dried up entirely.

Hale (1989:48-49) has suggested that water levels in Lake Okeechobee were lower from about 1000 B.C. - A.D. 100. He cites as evidence the fact that prehistoric archaeological sites around the lake have become inundated since their original formation. He cites several studies of late Holocene sea levels which indicate that a slight drop in sea level occurred at roughly this same time. Within the study area, Austin (1996a:70, 72) reported a hiatus in organic sedimentation underlying a prehistoric midden on Lake Arbuckle. Charcoal from a sand layer sandwiched between two strata of organic, silty muck was radiocarbon-dated at 2430 B.P., or cal. 760-400 B.C. He suggested that the sand strata may represent a period of lowered lake levels. On the other hand, approximately 750-1000 years ago, a period of extremely warm climate with increased hurricane activity is believed to have occurred (Gleason et al. 1974:311, Gribbin and Lamb 1978:70). The increased precipitation would have increased river flow and contributed to widespread flooding.

It is worth noting here that a recent analysis by Coleman (1982) of the relationship between rainfall patterns and temperature in peninsular Florida indicates that lower temperatures generally have resulted in a decrease in winter precipitation and extended drought conditions in south Florida because of a reduction in cyclonic activity. In general, the paleoenvironmental data seem to support an extension of this relationship into the distant past with periods of cooler average temperatures often associated with increased aridity.

As far as sea levels are concerned, there is a general consensus that sea-level rise slowed dramatically after 6000 B.P.; however, there are different opinions regarding the nature of this rise, i.e., whether it fluctuated periodically or was a relatively smooth transgression. The difference of opinion is based in part on the types of sediments (peat vs. beach ridges) that have been used to date this rise. I do not intend to go into detail regarding this controversy, and refer the reader instead to the extended discussions in Walker (1992:277-279) and Widmer (1988:149-154). Suffice it to say that there is increasing data from a number of independent sources that indicate that: 1) sea levels fluctuated by as much as 1-3 m throughout the late Holocene, and 2) that sea levels occasionally were higher than they are today (cf. Brooks et al. 1979; Colquhoun and Brooks 1986; Missimer 1973; Stapor 1991; Stapor and Tanner 1977; Tanner 1991; Walker 1992; Walker et al. 1994; Widmer 1986).

Summary

Based on the above review of regional hydrology and paleoenvironmental research, it is possible to make some generalizations regarding the effect of climatic variation on the water resources and wetland habitats of the study area (Table 2). Variation in precipitation, both seasonally and at the longer, multi-year scale, would have had the greatest effect on the availability of surface water and

Table 2. Paleoenvironmental history of south-central Florida.

Years B.P.	Sea Level	Climate	Water	Vegetation
15,000	-130 m to -100 m	Windy, cool, dry; 7-10 C cooler	No flowing water	Tropical sand-dune vegetation with scrub oak, rosemary, prairie grasses, and herbs
13,500	-80 m	Warmer, increased rainfall but still drier than today	Surface water limited to intermittent perched ponds and artesian springs; potentiometric surface -26 m to -11 m below present level	More mesic vegetation; first appearance of pine, palmetto, oak, hickory in uplands
11,000	-60 m	Extremely arid, warm; many fires	Limited surface water; water limited to artesian springs	
8500	-30 m	Summers warm, winters cool; increased rainfall	Permanent surface-water features began to form; organic sedimentation accumulated in upland lakes	Mesic oases around cenotes and lakes in otherwise arid, lowland plain; closed schlerophylous oak forest with prairie-like openings in uplands
5500	-4 m	Warmer than today, more rainfall	Many surface-water features; Kissimmee River began to flow regularly and Lake Okeechobee began to form; potentiometric surface near modern level	Pine replaced oak indicating more mesic conditions; cypress swamps began to form
3000	-1 m to + 1 m	Same as today	Maximum extent of freshwater; marshes and swamps abundant	Same as today, prior to modern alterations
Present	0			

associated wetland habitats. The most immediate effect would have been a reduction of surface runoff followed by a reduction in base flow if drought conditions existed and continued. Depression of the potentiometric surface as a result of extended periods of decreased rainfall and/or a lowered sea level would also have effected water sources. Since the region has few artesian springs, the principal effect would have been an increase in the vertical leakage of surface water, particularly in the upland lakes, and a reduction of base flow in lowlying recharge areas. The net result would have been increased desiccation. Thus, during the late Pleistocene and early Holocene, the study area was probably quite arid with limited surface-water features and a complete absence of the productive marshes and wetlands that are present today.

Because perched surface-water systems are more sensitive to short-term climatic changes than artesian water, it is likely that surface-water features may have been present at different times in the past even though sea level, and the potentiometric surface, were low (cf. Dunbar 1981 for a similar argument for the Hillsborough River basin). The lakes on the Lake Wales Ridge occupy a steep-walled valley and the local flow regime of both surface water and non- artesian ground water tends to be toward these land-locked basins (Lichtler 1972:17). Thus, they may have served as catchment basins during periods of increased precipitation, and may bave retained water for awhile even during drought periods when shallower ponds and streams went dry.

In the Kissimmee River valley, water sources would have been very sensitive to short-term climatic fluctuations. Shallow surface-water features may have held water during brief periods of increased precipitation but would have become desiccated quickly once rainfall diminished due to evaporation, reduced runoff, and a cessation of base flow. It was only after the climatic shift to increased precipitation at ca. 5000 B.P. that the modern wetland habitats that characterize the region began to form. By 3500-3000 B.P. they had assumed their present configuration, and save for minor climatic fluctuations, continued to exist until the present. The most significant of these fluctuations may have been the "Little Ice Age" which is believed to have occurred between 550 B.P. and 125 B.P. (Gribbin and Lamb 1978:69), resulting in cooler temperatures and a decrease in precipitation.

In the next chapter I discuss the regional geology with an emphasis on the formation and distribution of chert resources.

CHAPTER 4
GEOLOGY AND CHERT RESOURCES

Geologic History

The State of Florida is situated primarily on the Florida Platform which extends from the southern edge of the North American continent forming the northeast side of the Gulf of Mexico. About half of this platform is presently submerged, leaving a narrow peninsula jutting southward from the continental mainland. This land mass consists of a thick sequence of sedimentary rocks (limestones and dolostones) overlain by a thin veneer of siliciclastic sediments (quartz sands, silts, and clays).

The base on which this platform rests consists of crystalline rock (igneous and metamorphic) and sedimentary rock that were formed during the Cretaceous and earlier periods (Milton 1972; Scott 1992:2; Smith 1982). The highest point of the Florida basement is in west-central Florida at 1 km below the surface. The basement drops off dramatically near the center of the peninsula, and the deepest point is in south Florida at approximately -6 km (Puri and Vernon 1964:Figure 1; Smith 1982:Figure 2). Milton (1972:84, 92, 101, 109) reports that pre-Tertiary, Cretaceous rocks were encountered in wells drilled in Hardee, Highlands, and Okeechobee counties at depths ranging from -3 to -3.8 km.

Paleontological, lithological, geophysical, and geochemical data all indicate that peninsular Florida was once part of the ancient continent of Gondwana which consisted of Africa and South America (Smith 1982). Florida may have formed the leading edge of this continent when it and North America collided approximately 400-500 mya forming the megacontinent of Pangia. The resulting impact created the Appalachian Mountains. The suture line where the two continents collided may be located just north of Florida. Gravity anomalies to the north and south of this point trend in different directions, suggesting different origins for each area (Smith 1982:13). Separation of North America and Gondwana probably occurred around 200-250 mya. This separation is believed to have been caused by rifting and subsequent migration of the lithosphere as a result of an upwelling of molten magma (Smith 1982:15, 19). Geophysical data indicate that this "hot spot" of molten magma was located in the vicinity of south Florida. A three-way rift centered in this area left behind a wedge -- Florida -- when the continents were forced apart.

The deposition of carbonate sediments in southern and central Florida began at least 145 mya and continued until the late Oligocene, or about 28 mya (Scott 1992:2). Renewed uplift and erosion of the Appalachians during the late Oligocene and early Miocene resulted in an increase of siliciclastic sediments entering Florida via fluvial transport and becoming mixed with carbonate sediments.

The Miocene began during a period of lowered sea level and drier climate about 24 mya. Sea level subsequently began to rise, and by the middle Miocene it may have been at its highest point. Throughout the Miocene there were numerous periods of sea-level transgression and regression. These, coupled with the influx of siliciclastics from the north, resulted in a complex series of sedimentary deposits. During the late Miocene, siliciclastics dominated the depositional environment, eventually covering the entire Florida Platform (Scott 1992:6). These siliciclastics formed a relatively impermeable barrier that impeded the vertical movement of ground water, protecting the underlying carbonate rock from dissolution. Eventually, these sediments were breached by erosion allowing water to penetrate and dissolve the carbonate sediments resulting in the formation of solution cavities and other karst features. Opdyke et al. (1983) have suggested that the subsequent loss of limestone through subsurface dissolution and erosion have contributed to significant isostatic uplift of north-central Florida.

Florida's post-Miocene geologic history was influenced by a complex interaction of deposition and erosion. Sea-level transgressions resulting in marine deposition alternated with episodes of subaerial exposure, fluvial deposition, surface erosion, and solution collapse. These complex processes resulted in equally complex sedimentary deposits that exhibit evidence of extensive reworking in some areas (Cathcart 1966:23-26; Crissinger 1977; Scott 1988:112-118). Many of the resulting formations grade into one another laterally and are temporally equivalent. This has led to a number of different formation names that are unique to various regions of the state.

During the Pleistocene, sea levels continued to fluctuate creating terraces and scarps that are still preserved in some areas (Alt and Brooks 1965, Healy 1975). Despite periodic transgressions, there was a general downward trend in the sea-level curve during this time, resulting in progressively greater amounts of the Florida Platform becoming exposed to wind and water action. In the study area, siliciclastic sediments were being reworked and redeposited during the Pleistocene and Holocene while at the extreme southern end of the peninsula, carbonate deposition continued well into the Pleistocene.

Lithostratigraphy

The following discussion uses the lithostratigraphic nomenclature presented in Scott's (1992) overview of Florida geology. The lithostratigraphic units present in south Florida are summarized in Table 3.

From lowest to highest, the post-Cretaceous, Tertiary carbonate sequence in south Florida includes the Cedar Keys Formation, Oldsmar Formation, Avon Park Formation, Ocala Limestone, Suwannee Limestone, the Hawthorn Group, and the Tamiami Formation (Table 3). Overlying these are the Quaternary deposits of sand, shell, clay, peat, and limestone. Brief descriptions of the major formations are presented below with emphasis placed on those formations that are important to an understanding of chert resources in Florida.

Cedar Keys Formation

The Cedar Keys Formation was formed during the Paleocene when the sea covered all of Florida. It is not a pure limestone, as it contains primarily evaporites and dolomite (Scott 1992:19). The

Table 3. Lithostratigraphic units present in the study area (modified from Scott 1992:Figure 1).

System	Series	Age in millions of years	Lithostratigraphic Unit
Quaternary	Holocene	.01 to Recent	Undifferentiated Pleistocene-Holocene Sediments
	Pleistocene	1.6-0.1	Caloosahatchee-Ft. Thompson Formations
Tertiary	Pliocene	5.3-1.6	Tamiami Formation Citronelle/Cypress Head Formation
	Miocene	24-5.3	Hawthorn Group Peace River Formation Bone Valley Member Arcadia Formation Tampa Member Nocatee Member
	Oligocene	38-24	Suwannee Limestone
	Eocene	55-38	Ocala Limestone Avon Park Limestone Oldsmar Limestone
	Paleocene	67-55	Cedar Keys Formation
Cretaceous and Older		>67	Undifferentiated

environment of deposition was shallow to deep water. Preserved fossils are similar to those found in sedimentary deposits in Africa (Webb 1990:73), indicating that this carbonate unit probably formed prior to the separation of the continents.

Oldsmar Formation

During the subsequent Eocene, sea level dropped a bit, then rose again. The resulting sediments contain less clastics and dolomite, and more limestone, than the underlying Cedar Keys Formation. The basal formation in this series, the Oldsmar, consists of limestone interbedded with dolostone.

Avon Park Formation

Applin and Applin (1944) originally divided the middle Eocene deposits into two rock units: the Lake City Limestone and the Avon Park Limestone Miller (1986) later combined the two because of the similar nature of the sediments. This formation consists primarily of a fossiliferous limestone that was deposited about 45-50 mya. The environment of deposition was a very shallow sea that was affected by tides. At times the surface was exposed while at other times it was submerged. This formation is exposed only in Citrus, Levy, and Marion counties, making it the oldest rock outcrop in Florida. Although chert is occasionally encountered in this formation (e.g., Bishop 1956:93, 98-99), it is not significantly silicified. The lower part of the Avon Park Formation forms the sub-Floridan confining unit (Adams and Stoker 1985; Shaw and Trost 1984).

Ocala Limestone

Overlying the Avon Park Formation is the Ocala Limestone. Puri (1957; Puri and Vernon 1964:57-73) recognized three formations within this rock unit based on differences in fossil content. These biostratigraphic units include, from lower to upper, the Inglis, Williston, and Crystal River Formations. All are middle Eocene in origin and Puri included them all within his Ocala Group. Because of the difficulty in recognizing these units in the field, the formation names are no longer recognized by the Florida Geological Survey, and they have instead been lumped together as a single lithostratigraphic unit, the Ocala Limestone (Southeastern Geological Society Ad Hoc Committee on Hydrostratigraphic Unit Definition 1986).

Clark (1972.35, 38) and Scott (1992:23) recognize upper and lower divisions based on lithologic differences, with the lower being more granular in composition and dolomitic. The upper division contains numerous large foraminifera. Chert also is common in the upper Ocala Limestone with exposures limited to the Ocala Uplift in north-central Florida and the Chatahoochee Anticline in the northern panhandle (Puri 1957:Figure 7; Upchurch et al. 1982a Figure 2).

Suwannee Limestone

The Suwannee Limestone was deposited during the Oligocene, or between 24-38 mya. It is present throughout most of peninsular Florida extending into the panhandle, gradually sloping and thickening to the southwest (Cathcart 1966:9). It is absent in parts of central and northern Florida indicating that it was either eroded or not deposited there. Well borings in the Kissimmee River valley also indicate a pinching out of the Suwannee in that area (Bishop 1956:23). The lithology is a porous, granular limestone containing Echinoids, corals, many small foraminifera, and some mollusks (Puri and Vernon 1964:105-106). Portions of the Suwannee Limestone are silicified, and exposures are present throughout the western and northern peninsula (Upchurch et al. 1982a:Figure 2).

Hawthorn Group

The Hawthorn(e) Group is Miocene (ca. 24-5.3 mya) in age and consists of a complex sequence of phosphate-bearing sediments. It is present everywhere in Florida except on the Ocala Uplift and Sanford High (Scott 1988:Figures 5 and 6). Originally called the Waldo Formation by Johnson (1888), it was renamed the Hawthorne by Dall and Harris (1892) based on exposures in pits between Grove Park and Hawthorne east of Gainesville. Scott (1988) extended the temporal range of the Hawthorn to include early as well as middle and late Miocene deposits (although more recently he has suggested that the Hawthorn may extend into the Oligocene [Scott 1996]). In the southern peninsula, the Hawthorn has been divided into two formations: the lower Arcadia Formation and the upper Peace River Formation (Scott 1988:56-91, 1992:31).

Arcadia Formation. The Arcadia Formation is a carbonate deposit that includes the Nocatee and former Tampa Formation as basal members. The Nocatee includes what was formerly referred to in some geological reports as the "lower Tampa" or "Tampa sand and clay unit." Although its geographic extent is not known precisely, it does occur in some parts of south Florida (e.g., Campbell 1985a, 1985b; Wilson 1977) and is reported as far north as southern and eastern Hillsborough County and southwestern Polk County (Scott 1988 76). The Tampa Member overlies the Nocatee where it is present, and the Suwannee Limestone where it is not. It consists of a hard, dense, sandy limestone Fossil foraminifera, mollusks, and Echinoid fragments may be present. Scott (1992:31) notes that there also is a trend of increasing siliciclastic inclusions from west to east. Chert beds are common within the Tampa carbonate section with well-known exposures in the Tampa Bay and Hillsborough River areas (Cooke 1945; Goodyear et al. 1983; Heilprin 1887; Simpson 1939, 1941; Upchurch 1980; Upchurch et al. 1982a:139-140). Within the study area, the Tampa member of the Hawthorn has been encountered in wells drilled in Hardee County, Polk County, and the northern part of Highlands County (Bishop 1956; Cathcart 1966; Shaw and Trost 1984; Stewart 1966; Wilson 1977).

Clark (1972:41), following Cathcart (1964:12-16, 1966:9-15), includes all Miocene deposits in south Florida that are younger than the Tampa limestone within his Hawthorn Formation, and he divides the Hawthorn into a lower limestone member and an upper, unnamed clastic member. His descriptions of the two limestone units differ in that the Tampa is described as dolomitic with numerous fossils while the lower Hawthorn limestone notably excludes these attributes. In addition, the Hawthorn limestone is described as containing "sparse to locally abundant phosphate pellets and pebbles" (Clark 1972:41; cf. Cathcart 1966:9, 11). In Gurr's (1977:43) discussion of the Hawthorn (which he considers to overlie the Tampa limestone formation), he mentions that its lower carbonate member in Hardee and Manatee counties contains more chert than its equivalent in Polk and Hillsborough counties.

Scott (1988:65) felt that the differences between these limestone units (i.e., the Tampa limestone formation and the lower carbonate section of the Hawthorn) were not significant enough to distinguish between them, hence his inclusion of the Tampa limestone within the lower Hawthorn Group. Scott (1988:70) does mention, however, that the Tampa limestone contains noticeably less phosphate than the overlying carbonate section that he includes within the Arcadia Formation. The observations of these geologists regarding the lithologic differences between these two carbonate units are important in terms of chert identification as will be discussed in more detail in Chapter 7.

Peace River Formation The Peace River Formation is predominantly a siliciclastic deposit with abundant phosphate and some carbonates. It includes the former Bone Valley Formation as a basal member. Unusual depositional conditions occurred during the time that this formation formed as indicated by the presence of phosphate, palygorskite, opaline cherts, and dolomite (Scott 1988:102-123).

The Bone Valley Member is a sand-and-clay deposit that is best known as a source of phosphate in central Florida. It was originally named the Bone Valley Gravel by Matson and Clapp (1909), but because gravel makes up only a small portion of the deposit, subsequent investigators dropped this designation and assigned the more general term "formation" (e.g., Cooke 1945; Sellards 1915). The origin of the Bone Valley sediments is generally considered to be depositional (e.g., Pirkle et al. 1965), although others have suggested that it is a result of in-situ weathering of lower Hawthorn carbonates (e.g., Ketner and McGreevey 1959).

Geographically, Bone Valley sediments appear to underlie much of the Polk Uplands in Polk and Hillsborough counties (Campbell 1984, 1986). Gurr (1977:39) indicates that its southern extent terminates at Manatee, Hardee, and DeSoto counties. Clark (1972:51-52) concurs for the most part, but goes on to suggest that its relative absence south of the Polk Uplands is due to removal by erosion during the Pleistocene.

The Bone Valley sediments have traditionally been assigned to the Pliocene based mainly on terrestrial fossil content (e.g., Cathcart 1966:16; Crissinger 1977). Scott's placement in the upper Miocene is based on terrestrial and marine fossil evidence which he feels indicates an age range of early middle Miocene through possibly the early Pliocene (Scott 1988:84, 88-89, 1990:331).

Citronelle/Cypress Head Formation

The Citronelle Formation underlies the central ridge system of the Florida peninsula including the Lake Wales Ridge (Cooke 1945:229-238; Pirkle et al. 1963). It consists of gravelly sand, kaolin clay, and discoidal quartzite pebbles. It begins in Clay County and extends southward into Highlands

County. It also occurs in the panhandle. Klein et al. (1964.22-23) have suggested that quartz gravel beds encountered in wells as far south as Clewiston in Hendry County may represent a southern extension of these deposits. The type locality is in Alabama.

The Citronelle in Florida is a controversial formation. Some geologists question whether it is the "real" Citronelle. The panhandle Citronelle is unquestioned, but peninsular deposits are debated even though the two appear to be very similar in content. The age of the peninsular Citronelle also is a subject of debate. Cooke (1945:231) placed the Citronelle in the Pliocene. Bishop (1956:26) felt that the Citronelle was the terrestrial equivalent of the Hawthorn, and so was Miocene in origin, with both forming a large delta. Ketner and McGreevy (1959:49) placed the age of the Citronelle sediments of the Lake Wales Ridge as late Miocene based on fossil content. Puri and Vernon (1964:185-186) called it the Fort Preston Formation, placed it in the Miocene, and said it could not be traced into Alabama. Brooks (1974:261) argued that the Fort Preston type section is simply a filled channel within the Hawthorn, and he referred to the sand, clay, and gravel deposits on the Lake Wales Ridge as the Citronelle. Knapp et al. (1986) referred to these sediments as Coarse Clastics and considered them to be Miocene in age. Most recently, Scott (1992) renamed it the Cypress Head Formation, after the type locality in the Coastal Plain of Georgia (cf. Huddlestun 1988), and assigned it to the Pliocene. Adoption of this terminology has not been universal, although it appears in the recent soil survey of Highlands County (Carter et al. 1989).

According to E. C. Pirkle (personal communication, 1993), the Cypress Head in Georgia does not resemble the Citronelle of Central Florida. He believes the Citronelle to be a deltaic deposit, but unlike Bishop, he believes it to be post-Hawthorn in age (Pirkle et al. 1963, 1964, 1965). Subsequent high sea levels have eroded away flanking portions of the delta (cf. White 1970:112-113). Pirkle bases his conclusion on a number of lines of evidence including differences in composition, structure, and mineral content, all of which point towards two separate depositional episodes for the Citronelle and

Hawthorn (cf. Pirkle et al. 1963, 1965). Furthermore, late Miocene fossils exposed in sand mines near Davenport on the Lake Wales Ridge lie beneath the Citronelle, therefore, Pirkle has concluded that the Citronelle cannot be older than early Pliocene or late Miocene (E. C. Pirkle, personal communication, 1993).

Tamiami Formation

The Tamiami Formation is restricted to southern Florida. Parker (1951:823; Parker et al. 1955:85), Puri and Vernon (1964:212-213), and Hoffmeister (1974:24) considered it to be late Miocene in age; however, Scott (1992:35, Figure 1) includes the Tamiami Formation within his Pliocene series. He recognizes three lithologic divisions within the formation: the Pinecrest Sand Member, the Ochopee Limestone Member, and the Buckingham Limestone Member (Scott 1992:35-36). The Pinecrest is composed of fossiliferous, calcareous, quartz sand with variable amounts of phosphate. Well-preserved mollusk shells also are abundant. Both the Ochobee and Buckingham members are composed of slightly phosphatic, variably sandy, fossiliferous limestone with the only difference being that the former is more highly indurated than the latter.

It is unclear whether the Tamiami Formation occurs in the study area. Bishop (1956:15, Figure 4) shows a sand, clay, and shell unit that he identified as the Tamiami Formation overlying the Hawthorn in eastern Highlands County. Some geologists, however (e.g., Shaw and Trost 1984), consider these sediments to be part of the upper Hawthorn and so assign them to the late Miocene. Bishop's well data show this unit overlapping the Hawthorn sediments (both his marine and non-marine, or Citronelle, deposits) on the Lake Wales Ridge suggesting that it post-dates the formation of this feature, an interpretation that Klein et al. (1964:24) agree with. To the west, Clark (1972) does not mention this formation at all in his geological discussion of the Pine Level area of Manatee and DeSoto counties. Farther south, Brooks (1974:262), in his discussion of the lithostratigraphy underlying the Lake Okeechobee basin, identified the Tamiami Formation there, assigning it to the Pliocene. Similarly, Klein et al. (1964:24) identified this formation in cut banks along the Caloosahatchee River in Glades and Hendry counties, although they assigned it to the late Miocene.

Caloosahatchee-Fort Thompson Formations

Although Scott (1992:39-40) distinguishes between the Caloosahatchee and Fort Thompson formations, he notes that most geological investigations of south Florida do not. These formations consist of interbedded deposits of sand, shell, and limestone that were laid down during the late Pliocene and early Pleistocene. The limestones were deposited under both freshwater and marine conditions, reflecting variation in sea levels.

According to Klein et al. (1964:25), the geographic distribution of the Caloosahatchee Formation is not well known. Scott (1992:39) indicates that it exists over much of south Florida, extending up the west coast as far as Tampa. The Fort Thompson Formation appears to be restricted to the Caloosahatchee-Lake Okeechobee-Everglades region of south Florida (Brooks 1974:263-264; Hoffmeister 1974:Figure 2; Klein et al. 1964:27-29; Parker 1945:Figure 2). Neither of these formations appear in geologic discussions of the study area (e.g., Bishop 1956; Cathcart 1966; Clark 1972; Shaw and Trost 1984; Stewart 1966; Wilson 1977), although many of these investigators may have chosen to include them within their undifferentiated Pleistocene sediments.

Undifferentiated Pleistocene and Holocene Sediments

These surficial deposits consist most often of quartz sands, but may also include clay beds, shell beds, peat deposits, and freshwater carbonates. Thicknesses may vary from a few meters to nearly a hundred meters with thicknesses increasing to the north in the Central Highlands. On the Lake Wales Ridge, for example, the upper sand deposits can be as much as 60 m (200 ft) thick (Briane and Stoker 1985:Figure 3) while in southern Hardee County they are generally between 1.5-9 m (5-30 ft) in thickness (Cathcart 1966; Lane et al. 1980).

Pleistocene sediments are the result of marine deposition during transgressive periods, and both erosion and aeolian transport during intervening periods of subaerial exposure. In the Pine Level region of Hardee and DeSoto counties, Clark (1972:64-65) distinguishes between two lithologically distinct Pleistocene units: a lower, phosphatic, sand-and-clay unit and an upper, slightly clayey sand that contains no phosphate.

In the Trail Ridge area of north-central Florida, wood fragments in sands overlying the post-Hawthorn clastic deposits of clay, sand, and phosphorites have been radiocarbon dated at 31,400± 500 B.P. (Pirkle et al. 1970:26). The wood fragments were at 18.2-18.9 m (60-62 ft) below the modern land surface. In south-central Florida, Watts and Hansen (1988) report radiocarbon dates on charcoal from submerged silty deposits in lakes which indicate that these were being infilled by windblown deposits as early as 40,000 B.P.

Holocene deposits are the result of the reworking of earlier sediments by aeolian action, fluvial transport, and solution. Significant peat deposits are located south of Lake Istokpoga in Indian Prairie (Davis 1946:129-132). These are believed to have formed within the past 6000 years. This conforms with palynological and geological data from south Florida which indicate that relatively modern climatic conditions with associated surface-water features and vegetative complexes did not occur until 5000 years ago (Gleason et al. 1974:310-311; McDowell 1969; Watts 1971, 1975; Watts and Hansen 1988).

Chert Origins and Distribution

Chert is a sedimentary rock composed primarily of silica (SiO_2) with minor amounts of various impurities. Chert occurs in nature in three forms or mineral phases of silica -- quartz, chalcedony, and opal. These different phases represent a sequence of silica maturation with opal being the least stable form and quartz the most stable. The sequence is characterized by increasing grain size, more distinct grain boundaries, the segregation of impurities to grain boundaries, and decreasing water content from opal to quartz (Carozzi 1993:147-148, Folk and Weaver 1952:498, Upchurch et al. 1982a:47-54, 1982b:273).

The precise mechanism(s) of chert formation has been the subject of much research and debate, and several models of chert formation have been proposed (e.g., Carver 1980; Eugster 1967; Knauth 1979; Strom et al. 1981; Upchurch et al. 1982b; Weaver and Wise 1974; and reviews in Carozzi 1993; Hesse 1989; Upchurch et al. 1982b). As Hesse (1989) points out, the formation of chert is a complex process, and all of the proposed models have been supported with empirical data. What appears to be the case is that chert can and will form in a variety of different contexts under a number of different conditions, and thus no one model is applicable to all chert formations.

Carozzi (1993:148) has classified silicious rocks into three categories based on their presumed modes of origin: 1) silicious rocks of primary biogenic origin, 2) siliceous rocks of primary inorganic origin, and 3) siliceous rocks of secondary replacement origin. In the Atlantic and Gulf Coastal Plain of the southeastern United States, including Florida, it is the first and third categories of siliceous rocks that are the most common. The one constant element that is critical to the formation of chert is a source of soluble silica. Biogenic silica is considered the most likely source in the two categories of chert that are common in the Coastal Plain region. It is believed that most biogenic silica is the result of the dissolution of the hard parts of silica-secreting marine organisms. These organisms (diatoms, Radiolaria, siliceous sponges) extract silicon from sea water to build their tests (e.g., Carver 1980; Weaver and Wise 1974). These tests consist of a form of amorphous silica, known as opal-A, which, because it is relatively unstable, is subject to dissolution. A large proportion of the opal-A produced by silica-secreting organisms returns to the ocean via dissolution and is endlessly recycled by succeeding generations of these organisms.

Another possible silica source is the weathering of clay minerals. Altschuler et al (1963) studied weathering of clays in Florida and concluded that the conversion of montmorillonite to kaolinite resulted in a loss of silica which could have contributed to the silicification of underlying limestones. Although Upchurch et al. (1982b) consider weathering of the Hawthorn clays as a major source of silica, they express doubt as to whether the process described by Altschuler et al. would produce opal or quartz fabrics suitable for the formation chert, more likely is the dissolution of biogenic silica (Upchurch et al. 1982b:257, 259).

A third potential source is the alteration of clastic volcanic sediments in submarine environments (Garrison 1974; Gremillion 1965). This model has been applied to the study of both deep sea and Coastal Plain cherts, but its significance as a major source of chert-forming silica was refuted by Wise and Weaver (1974). The amount of silica produced by submarine volcanic systems is relatively insignificant in comparison with the widespread distribution of biogenic silica in sea water, and the distribution of these volcanic systems is inconsistent with the distribution of submarine siliceous oozes. Furthermore, petrographic analysis of Florida limestone and chert samples has failed to reveal evidence of volcanic glass (Nuckels 1981:69; Reik 1982:250).

Other viable silica-source models include the precipitation of silica resulting from the mixing of carbonate waters with salt water in coastal areas (Knauth 1979) and direct precipitation in alkaline lakes (Eugster 1967; Peterson and von der Borch 1965). According to Nuckels (1981:71), the fact that Florida cherts are not stratigraphically continuous and are in close proximity to the clay weathering surface indicates that the former model does not apply. The last model, however, does seem to be applicable to the formation of some Florida cherts as will be discussed in more detail below.

Upchurch et al. (1982b) have reviewed the various competing models and compared them for their applicability to Florida. They conclude that in Florida the most likely source of silica is the dissolution of biogenic opal-A. They consider the phosphatic, clay-sand unit of the Hawthorn Group to be the primary source of silica for chert formation since it is known to contain silica-rich clay minerals and siliceous fossils. Its distribution is widespread in Hillsborough, Manatee, Sarasota, DeSoto, Polk, and Hardee counties, and it occurs as scattered erosional remnants elsewhere in the peninsula (Scott 1988:Figures 5 and 6; Upchurch et al. 1982a:19, Figure 2).

Model of Chert Formation in Florida

Research conducted by Sam Upchurch, Richard Strom, and their students at the University of South Florida (Nuckels 1981; Strom et al. 1981; Upchurch et al. 1982b) has resulted in data that have led to the development of a model of chert formation in Florida. A detailed presentation of this model is presented in Upchurch et al. (1982b), and a more general summary is available in Upchurch et al. (1982a).

Their model suggests two phases of chert formation. The first occurred during the Miocene while the Hawthorn was being deposited. It produced primary opaline cherts and porcellanites within the upper Hawthorn, and replacement cherts in limestone within and immediately beneath the Hawthorn. The second occurred later and may still be occurring. It is the result of weathering of the Hawthorn clay mantle and vertical precipitation of silica into the underlying limestone. Silica replacement of limestone is believed to be the major cause of chert formation in Florida.

Precipitation of opal in alkaline lakes. The opal-rich chert deposits that occur throughout the upper Hawthorn Group appear to underlie former alkaline lake beds that contained silica-rich sediments. The lake beds formed during periods of sea-level regression during the Miocene. The silica is thought to be the result of dissolution of diatom frustules and sponge spicules which contain amorphous opal (opal-A). Diatom fossil molds are common in Florida cherts and they are known to be present throughout the Hawthorn sediments (Hoenstein 1984:12). There is less direct evidence for sponge spicules; however, Upchurch et al. (1982b:261) note the presence of spicules in a thin-section of chert from the Tampa Bay area, and so conclude that sponge spicules also could have been a source of silica.

Exposure to fresh-water environments stimulates the dissolution of the unstable opal-A. As part of the normal maturation process (i.e., the process of mineral stabilization), opal-A transforms to opal-CT (a more stable phase of silica that contains cristobalite and tridymite) through dissolution and reprecipitation. According to Upchurch et al.'s theory, water filtering through the silica-rich sediments that lined the lake bottoms percolated down into the underlying limestone. These silicious fluids permeated the limestone beneath the lakes, filled voids and cavities with opal, and eventually replaced the limestone altogether. Opal-CT in the replaced limestone eventually recrystallized through solid-state inversion (i.e., transformation without the aid of water as opposed to dissolution and reprecipitation) to form microcrystalline quartz, although much of the chert contained in the Hawthorn retains a high opal content.

Another episode of chert formation occurred during silicification of in-situ, silica-rich sediments in the alkaline lake bottoms. During arid periods when lake waters evaporated, the clayey lake bottoms dried and cracks appeared. These cracks became coated with opal precipitating out from the surrounding silica-rich sediments and eventually hardened. The type of silicious rock that resulted is referred to as "box-work" geodes because of its brecciated appearance (Strom et al. 1981). The clay between the cracks is often pure palygorskite which has not silicified because most of the silica has precipitated out. In deeper layers of the clayey lake bottoms, where no or very few cracks occurred, the opal contained within the clay hardened and welded the palygorskite (a clay mineral characterized by rod-shaped crystals, i.e., fibrous clay) fibers together. This type of silicious rock is known as porcelanite.

Weathering of Hawthorn clays. Since the marine sediments of the Hawthorn contain a high concentration of silica-rich clay minerals and silicious fossils, they also are potential sources of unstable silica that contributed to chert formation (Scott 1981). Following the Miocene, non-marine sediments accumulated and buried both the Hawthorn sediments and the chert zones. Subsequent percolation of ground water through these overlying sediments into and through the Hawthorn clays resulted in weathering and dissolution of unstable silica. The resulting siliceous fluids permeated the underlying limestone and eventually replaced it. The opal-CT in these replacement rocks eventually recrystallized into quartz. In possible support of this model Upchurch et al. (1982b.259) cite the work of Lawrence (1976) who has shown that in north Florida, ground-water that has been in contact with Hawthorn clays tends to have inflated levels of silica.

Distribution of Chert in Florida

In Florida, most of the chert exposures that were exploited by prehistoric peoples are restricted in their areal extent to the Ocala Uplift and the Chattahoochee Anticline, geomorphic features that encompass much of the central peninsula of the state and portions of the Big Bend area of the panhandle, respectively. The major chert-bearing formations in Florida are the Ocala Limestone (especially the upper Crystal River biostratigraphic zone), the Suwannee Limestone, the Tampa Member of the Hawthorn Group, and the upper sand-clay unit of the Hawthorn (Scott's Peace River Formation in south Florida). Chert also has been identified in the Avon Park Limestone (e.g., Bishop 1956:93, 98-99), but at depths too great to have been exploited by prehistoric people. These rock units generally slope to the west with the oldest, the Avon Park, exposed in Citrus, Levy, and Marion counties, followed, from east to west, by the Ocala, Suwannee, and Tampa. The upper sand-clay unit of the Hawthorn is exposed in stream beds throughout much of south-central Florida (Cathcart 1966; Clark 1972; Lane et al. 1980).

Silicified deposits tend to be discontinuous and localized, with exposures occurring in stream channels or in coastal areas where water action has removed overlying sediments, in sinkholes that have breached chert-bearing limestones, and on the crests of hills and ridges where erosion of the overlying sandy sediments have exposed near-surface limestone. Several aboriginal quarry sites are known to be present in inundated contexts in the Gulf of Mexico (Goodyear et al. 1980, 1983; Upchurch et al. 1982a; Warren 1968) providing indirect evidence of offshore chert outcrops. No major chert outcrops are known for the area south of a line running through central Manatee, central Hardee, and northwest

Polk counties (Lane et al. 1980; Tom Scott, personal communication, 1993; Upchurch et al. 1982a), although small, isolated exposures may be present (E. C. Pirkle, personal communication, 1993).

According to Upchurch et al. (1982b:261), this restricted range is the result of three factors: 1) the distribution of siliceous Hawthorn clays, 2) the juxtaposition of suitable limestone deposits with the Hawthorn, and 3) conditions of geological uplift. Since most of the chert in Florida appears to be the result of silica replacement of limestone, the limestone must be in close stratigraphic proximity to the source of silica (i.e., the Hawthorn clays) for this replacement to occur. Thus, the geographic distribution of the Hawthorn, and the juxtaposition of suitable limestone deposits beneath it, are both necessary for chert to form. Uplift of the strata also is necessary to accelerate weathering of the Hawthorn clays, increase the potential for vertical precipitation of silica-enriched ground water, and expose the underlying limestones to the effects of replacement. These factors coincide and reach their maximum expression along the Ocala Uplift and Chatahoochee Anticline and tend to be absent elsewhere.

Potential for chert in the study area. A review of the geological literature of south Florida indicates no references to surface or near-surface deposits of chert on the Lake Wales Ridge, in the Kissimmee River basin, or in the Lake Okeechobee basin. The only significant chert exposures near the study area are located in the channel of the Peace River where stream erosion has exposed silicified dolosilts within the Hawthorn (Upchurch et al. 1982a:145, 147, Figure 2). Chert outcrops have been identified in several locations along the river as far south as Zolfo Springs just east of Pioneer Park (Tom Scott, personal communication, 1993; personal observation, 1993). Chert outcrops also are located at Ft. Meade and Kissengen Springs, both of which are known prehistoric quarry sites (Chance 1980:12-18; Upchurch et al. 1982a:145). Another chert outcrop is reportedly located along the river near Wauchula. Samples of this material were given to me by an informant, although I have not personally observed the exposures.

Cathcart (1966:6, Plate 1) states that the Hawthorn has been exposed by downcutting in the Peace River and along many of its tributaries including Whidden, Bowlegs, Little Payne, Payne, Little Charlie, Troublesome, and Brushy Creeks; however, his geologic cross-sections (1966:Plate 1) indicate that the Hawthorn is covered by sand in all but the Peace River. It is possible, however, that in the prehistoric past, isolated, chert-bearing outcrops within the Hawthorn may have been exposed in these tributaries. Milanich et al. (1975:10) report small exposures of chert around the edges of bayheads and along stream banks in northwestern Hardee County; however, the absence of any reported quarry sites away from the river indicates that these exposures were not used extensively by prehistoric peoples.

To the north of the study area, the closest chert sources are located in northwestern Polk County where exposures of silicified Suwannee and Ocala limestone are present (Stewart 1966:14-15; Upchurch et al. 1982a:132, Figure 2). To the northwest are chert resources associated with the lower limestone unit of the Hawthorn (i.e., the Tampa Limestone Member). Chert exposures within this rock unit have been observed as far south as the Alafia River (personal observation, 1990). Leighty et al. (1958:Map 94) indicate that limestone exposures are present along the Little Manatee River in southern Hillsborough County, but although chert is suspected (Upchurch 1981), none has been confirmed.

Anecdotal reports of chert outcrops in areas outside of the main chert-bearing region of the state, or in geological deposits not generally considered to be chert-bearing, have been conveyed to me by several individuals. E. C. Pirkle (personal communication, 1993) has indicated that he has observed chert in sand mines along the northern Lake Wales Ridge and in a mine near the Econlochatchee River in Orange County. For these occurrences to be significant archaeologically, the deposits would have to be either at, or very near, the ground surface (i.e., within a meter or two) to have been exploited prehistorically using primitive tools. Unless the chert was exposed by stream erosion or in the walls of a sinkhole, it is doubtful that prehistoric peoples would have known of its existence. Thus, the depth of the chert in these mines would be of critical importance in evaluating whether these occurrences would have been important archaeologically

In his study of the ground-water resources of Highlands County, Bishop (1956) provides geological data derived from over 400 well borings. Boring logs of these wells indicate the presence of chert in his lower Hawthorn Formation (above the Tampa limestone unit) at depths ranging from 90-180 m (ca. 300-600 ft) below ground surface (Bishop 1956:15, 79-113). The chert usually is described as dark in color, sometimes dark brown, and the associated matrix is often highly phosphatic. This description is similar to the cherts found typically in the Peace River outcrops (Upchurch et al. 1982a:145-147). If the mining activities described by Pirkle exposed chert that is related to these deposits, then its extreme depth below ground surface would have made it inaccessible to prehistoric people. Bishop's logs also indicate chert in the Suwannee, Ocala, and Avon Park limestones; however, the extreme depths of these deposits on the Lake Wales Ridge makes it highly unlikely that they were ever exploited by prehistoric flintknappers. The shallowest occurrence of chert in any of the boring logs (5.5-7.6 m, or 18-25 ft) is at a well located 7.5 km west of Lake Annie (Bishop 1956:106). Although shallow in geological terms, this depth would have inhibited prehistoric exploitation unless exposed in stream channels or sinkholes.

Several individuals informed me of possible limestone outcrops in or along the margins of some of the lakes located on the Lake Wales Ridge in Highlands County. Two of these outcrops were visited by me in order to verify whether or not limestone, and perhaps chert, was indeed present. In both cases, the outcrops turned out to be poorly consolidated deposits of sandstone. During a recent archaeological survey of Highlands County (Janus Research 1995a), nodules of what appeared to be a sandy, siliceous stone were observed in roadside cut banks in two locations on the east side of the Lake Wales Ridge. Samples of this material were collected and examined microscopically. They also were subjected to acid and scratch tests. The samples turned out to be silicified sandstone and/or sandy dolostone.

Thus, both the geological data and empirical observations in the field confirm the absence of surficial or near-surface chert deposits in the primary study area. The conclusion is that while small, isolated exposures of chert may have been present in south Florida, it is considered doubtful that these would have constituted very significant lithic sources. This conclusion is supported by an analysis of the raw materials represented in the archaeological assemblages included in this study.

CHAPTER 5
PREHISTORY OF THE STUDY AREA

The Kissimmee region has, until recently, occupied an ambiguous position in most researchers' attempts to synthesize the prehistory of south Florida (cf. Carr and Beriault 1984; Goggin 1941, 1947a, 1948a, 1948b, 1949a, 1949b; Griffin 1988, 1989; Milanich and Fairbanks 1980; Widmer 1988), due in large part to the relative lack of substantive research in this part of the state. Most of what is known about the area comes from the work of early explorers (e.g., Conklin 1875; Kinnaman 1912; Le Baron 1884), avocational archaeologists and collectors (e.g., Benson 1967; Moore 1905; Watson 1948), and more recently the efforts of archaeologists conducting cultural resource management surveys (e.g., Austin 1987; Austin and Ballo 1987, 1989; Austin and Fuhrmeister 1990; Austin and Hansen 1988; Austin and Piper 1986; Austin et al. 1994; Janus Research 1995a, 1996a). Excavations are limited in number and have focused on sites associated with the late prehistoric Belle Glade culture (Austin 1993; Austin et al. n.d.; Griffin and Smith 1948; Sears 1982). Recent problem-oriented research (Austin 1996a; Johnson 1991, 1994, 1996; Mitchell 1996) have added immeasurably to an understanding of the region's post-Archaic archaeology, but the period prior to about 3000 B.P. remains poorly known.

Integrative Concepts: Tradition and Horizon

In the following discussion of the prehistory of the study area, I utilize the concepts of tradition and horizon as integrative devices for arranging the existing culture-historical data. This differs from the more common practice of using temporally distinct culture periods or stages of development (cf. Goggin 1947a, 1948a, Milanich 1994; Milanich and Fairbanks 1980; Willey 1949a). The tradition concept was first used in Florida by John Goggin who described it as "a distinctive way of life, reflected in various aspects of the culture; perhaps extending through some period of time and...showing a basic consistent unity" (Goggin 1949a:17). Willey and Phillips (1958:37), recognizing that technological or social traditions may encompass more than one culture, refined the definition to one that is primarily a "temporal continuity represented by persistent configurations in single technologies or other systems of related forms." The tradition, therefore, recognizes similarities in technology and behavior within a (relatively) circumscribed geographic area over a long period of time (Willey and Phillips 1958:34-38; see also Caldwell 1958:3).

An important component of Goggin's use of the tradition concept is his explicit reference to "environmental relations" in his descriptions of the various cultural traditions in Florida. While he is careful to avoid charges of determinism, he recognized nonetheless that "close relationships do exist between man and his land" and that in Florida "the environment through its capabilities and limitations has exerted a permissive influence on the Florida native and his culture. Moreover, this influence was not static; a series of changing ecological situations resulted in many factors of direct importance to man" (Goggin 1949a:18). In other words, Goggin viewed these cultural traditions (ways of life) as adaptations to changing environmental conditions.

The horizon concept as defined by Willey and Phillips (1958:20-34) is an integrative unit that recognizes roughly contemporaneous similarities in technology or behaviors over a wide geographic area. Thus, the tradition expresses time depth while the horizon expresses geographic breadth (Willey and Phillips 1958:38). The horizon concept has not seen wide usage in Florida, as least explicitly, although in an implicit way all archaeologists utilize it to order their data (see, for example, Goggin's [1949a] discussions of historical relationships within his various cultural traditions). One explicit use of the horizon concept is by Widmer (1988) in his overview of south Florida prehistory.

Both of these integrative units were developed to order space-time relationships in prehistory, a necessary prerequisite before one can attempt interpretation. Any such ordering inevitably encounters problems because of the wide range of variability that is inherent in human culture. Any system that attempts to summarize cultural data spatially or temporally must run the risk of obscuring this variability. One of the advantages of using the tradition and horizon concepts as integrative devices is that while they emphasize similarities through space and time, they also are capable of identifying the discontinuities that inevitably appear when one attempts to extend horizons into geographically remote areas or monitor the persistence of traditions through time. They are useful for generating hypotheses regarding the dynamic processes that resulted in the observed patterns, as well as those that created the observed discontinuities (Caldwell 1958:2). Thus, they should be viewed as heuristic tools for ordering and thinking about the past.

Another advantage is that their use does not, in and of itself, imply directionality in the evolutionary process. Unfortunately, any temporal ordering of archaeological data within a geographic area, no matter how large or small, conveys the impression of directionality even when none is intended. Criticism of Willey and Phillips's "stage" concept, for example, has focused on its implied notion of "progress" from simple to more complex while at the same time masking the fact that contemporary societies within a geographic region can exhibit different stages of development (Trigger 1990:58, 110. 146-147, 329-336). This criticism is perhaps more an indictment of the use of the stage concept rather than its intellectual genesis since Willey and Phillips were careful to separate "stage" from "chronology" (Willey and Phillips 1958:65-72), recognizing that while "cultural development has a time dimension. .this dimension is not necessarily uniform for all localities or regions of an area" (Willey and Phillips 1958 66). Regardless of the original intent, use of the stage concept has led to a misunderstanding of evolutionary processes. By using the "tradition" and "horizon" concepts, I hope to avoid, or at least minimize, these problems while, at the same time, highlighting the discontinuities that can stimulate further research.

Prehistoric Occupation of the Study Area

Paleoindian Tradition (13,000-10,000 B.P.)

Goggin's (1949a) original definition of the Paleoindian tradition in Florida bears repeating here since it continued to serve as the dominant paradigm for thinking about this early way of life until relatively recent times (e.g., Milanich and Fairbanks 1980:38). According to Goggin (1949a:20), "The Paleo-Indian tradition is that of a simple nomadic or semi-nomadic group depending on hunting and fishing, and probably to a lesser extent on wild foods." Goggin (1949a:20) continues by identifying central Florida as the geographic center of the tradition based on the distribution of lanceolate-shaped projectile points, and observes that most of these early projectile points are found near water. Subsequent definitions added the hunting of Pleistocene megafauna to the definition (e.g., Willey 1966:37-38, 457), based primarily on the association of lanceolate-shaped projectile points (Clovis, Folsom, Cumberland) with extinct fauna in the far west. Recent syntheses of the Paleoindian tradition in the Eastern United States describe it as an adaptation to the terminal Pleistocene climate, landscape, and associated fauna and biota (Anderson et al. 1990, 1996; Bense 1994:38-54, Goodyear et al. 1993:23; Lepper and Meltzer 1991).

Recent research has confirmed Goggin's contention that the karst region of central and northern Florida contains the greatest abundance of Paleoindian sites, and that most of these are associated with sources of permanent fresh water (Dunbar 1991; Dunbar and Waller 1983). Paleoenvironmental data, unavailable in Goggin's time, indicate that lowered sea levels and an arid landscape confronted Florida's first inhabitants, making the few sources of permanent water available in springs and spring-fed rivers a major attraction for both humans and the animals they hunted. However, it is now clear that the

Paleoindian settlement and subsistence patterns were more complex than previously believed, both in Florida and throughout the southeastern U. S. (Anderson 1996; Anderson and Sassaman 1996a). Following Binford (1980), Daniel (1985; Daniel and Wisenbaker 1987:173-175) has hypothesized that Paleoindian people in Florida practiced a logistical settlement strategy characterized by the establishment of semi-permanent habitation sites and the movement of resources from their sources of procurement to the habitation site via special task groups. Subsistence data indicate that while Paleo-indians did exploit extinct species such as mammoth, mastodon, ground sloth, tapir, horse, and camelids, they also ate deer, snake, opossum, raccoon, rabbit, gopher tortoise, fish, and shellfish (Science Applications, Inc. 1981:185-193; Milanich 1994.47).

Suwannee Horizon (12,000-10,000 B.P.). The earliest Paleoindian manifestation in peninsular Florida, referred to here as the Suwannee horizon, is recognized archaeologically by the presence of large, lanceolate-shaped Suwannee and Simpson projectile points (Bullen 1975:55-56; Daniel and Wisenbaker 1987:44-54; Purdy 1981:8-10). Other artifacts diagnostic of this horizon include a variety of unifacial scrapers (end, side, oblong, discoidal), bifacial and unifacial adzes, hafted spokeshaves, unifacial retouched flakes, flakes with beaked projections, and blade-like flakes (Daniel and Wisenbaker 1987:62-88; Purdy 1981:11-22). Widmer (1988:58) has referred to the early Paleoindian period in south Florida as the Clovis horizon, yet there is only limited evidence for a true Clovis occupation in Florida (Goodyear et al. 1983:46; Daniel and Wisenbaker 1987:149), and this seems to be restricted to north Florida (Bullen 1962:Figure 1, 1969:Figure 1, A. Goodyear, personal communication, 1996; Neill 1964). On the other hand, Suwannee and Simpson projectile points are widespread throughout central and north Florida, as well as parts of the southeastern U.S. (Anderson 1996:Figure 3.3; Anderson et al. 1990:45-89; Anderson and Sassaman 1996b:Figure 11.3; Bense 1994 Figure 4.6; Dunbar and Waller 1983; Goodyear et al. 1983; Ledbetter et al. 1996:279-281; Robinson 1979; Powell 1991). While Stanford (1991:9) has proposed that Clovis in the Eastern United States was an outgrowth of an earlier

Suwannee Horizon, this view is not widely held The more conventional interpretation is that Clovis is earlier than Suwannee (A. Goodyear, personal communication, 1996). Daniel and Wisenbaker (1987:149) conclude that occupation of Florida during the Clovis Horizon was limited and that the Suwannee Horizon represents the first, large-scale occupation of Florida by humans.

Most of the information about Paleoindian settlement patterns, subsistence strategies, and technology come from the karst region of central and north-central Florida (e.g., Daniel and Wisenbaker 1987; Daniel et al. 1985; Dunbar 1991; Dunbar and Waller 1983; Goodyear et al. 1983; Hoffman 1983; Neill 1958, 1964; Simpson 1948, Webb et al. 1983, 1984). The evidence for human occupation of the study area, in fact for all of south Florida, during the late Pleistocene is limited. The only securely documented site dating to this time period is Little Salt Springs in Sarasota County. Clausen et al. (1979:609, Table 1) reported that a wooden stake that penetrated an extinct land tortoise was radiocarbon dated at 12,030 ± 200 B.P. while the turtle carapace was dated at 13,450 ± 190 B.P. A peat layer below a human burial was dated at 10,980 ± 210 B.P.

A second possible Suwannee Horizon site is Warm Mineral Springs. Cockrell and Murphy (1978:Figure 3) report eight radiocarbon dates older than 10,000 B.P. from Warm Mineral Springs including a human burial from the "13 meter ledge" which was dated at 10,319 B.P.; however, the remaining eight dates from this ledge cluster between 10,000 B.P. and approximately 8300 B.P. Clausen et al. (1975:197, Table 2) report eight dates from Zone 3 of the "13 meter ledge" at Warm Mineral Springs that range from 10,630 ± 210 B.P. to 9370 ± 400 B.P. and two dates of 8600 ± 400 B.P. and 8520 ± 400 B.P. from the overlying Zone 2. Finally, a human pelvis reportedly collected from a 20 m (65 ft) ledge at Warm Mineral Springs by William Royal has been dated by the amino acid racemization method at 10,500 B.P. (Lien 1983); however, the large standard error for this sample (± 1700 years), makes it of little value in evaluating the age of this site. More recently, Cockrell (1990:74-76) has reported additional radiocarbon dates from Zone 3 of the "13 meter ledge." These range from

10,980 ± 40 B.P. to 10,240 ± 80 B.P., with the oldest coming from an isolated human mandible. The relatively tight clustering of dates around 10,000 B.P. has led Widmer (1988:61-62) to place this site in the late Paleoindian, or Dalton Horizon; however, the side-notched projectile points found at Warm Mineral Springs are more typical of the succeeding early Archaic Bolen Horizon (see discussion below). Thus, it appears that Warm Mineral Springs was occupied during the transition from the terminal, late Paleoindian, Suwannee Horizon to the succeeding, early Archaic, Bolen Horizon.

The only site in south Florida where Suwannee points have been excavated in good stratigraphic context is the Helen Blazes site in Brevard County (Edwards 1954). Here, Suwannee points were found in the lowest excavated levels on what Edwards (1954:25) refers to as an "eroded" surface. Overlying the Suwannee points were "Eared Suwannee points" which Bullen (1958:30) suggests actually may be side-notched Bolen points.

Within the study area, archaeological evidence for an early Paleoindian presence area is equivocal as it is limited to a few isolated artifacts. A lanceolate-shaped, Simpson projectile point was recovered from spoil dirt during excavation of a cattle pond near Arbuckle Creek on the Avon Park Air Force Range (Austin 1987:Figure 2); however, intensive subsurface testing of this site in 1994 failed to discover an intact Paleoindian component (Janus Research 1994a). A similar Simpson-like projectile point was recovered during testing of the Gum Swamp 6 site in Hardee County (Janus Research 1995b:63-65, Figure 26), but the stratigraphic context of this artifact suggests possible salvage and reuse by later, Archaic period people. Both of these sites also contained heavily reworked, middle Archaic projectile points (Austin 1987:Figure 2; Janus Research 1995b:65-66, Figure 26, Kolodgy n.d.). Several lanceolate-shaped, Paleoindian projectile points that reportedly were collected from the Peace River area are on display at the Pioneer Museum at Zolfo Springs. Unfortunately, no other information about the contexts of these finds is available.

Little else is known about this early horizon in south Florida because of an absence of sites. Widmer (1988:60) has suggested that the earliest inhabitants of south Florida relied on perishable bone and wood tools, making it difficult to locate terrestrial sites dating to this horizon. However, without durable raw materials such as stone, the procurement of plant and animal products and their manufacture into tools would have been difficult. A more likely explanation for the lack of sites is that the extremely arid conditions that prevailed in south Florida made the area unattractive for human occupation. The fact that most of the known Suwannee-horizon sites in Florida are located where both permanent water in artesian springs and high-quality, lithic resources were available suggests that the settlement pattern was one in which Paleoindian populations were "tethered" to these critical resources (Daniel 1985:264; Daniel and Wisenbaker 1987:169; Dunbar 1991; Goodyear et al. 1983). The logistical settlement strategy proposed by Daniel (1985; Daniel and Wisenbaker 1987) is best suited to landscapes where critical resources are patchily distributed (Binford 1980; Kelly 1983). The fact that so few Paleoindian sites have been recorded in south Florida suggests that limited precipitation, lowered sea levels, and regional geology combined to create a landscape poorly suited for this type of settlement strategy; that is, both permanent water and lithic materials suitable for the manufacture of tools were limited or non-existent. Thus, the relatively intensive occupation evidenced in north and central Florida during this period does not seem to have occurred in south Florida. The existence of early occupations at Little Salt Springs and, perhaps, Warm Mineral Springs, suggests that, at best, limited forays into the region were made for the purpose of exploiting local resources.

Archaic Tradition (10,000-3000/2500 B.P.)

Some archaeologists (e.g., Bense 1994:58; Purdy and Beach 1980:114-115; Widmer 1988:60-62) have suggested that the late Paleoindian Dalton Horizon succeeded the Suwannee Horizon in Florida. Bullen (1975, 1976) also recognized a Dalton Horizon in Florida, but argued that it should not be included within the Paleoindian Tradition because of the prevalence of beveling and serrations on

Dalton projectile points, a resharpening technique that was not practiced during the earlier Suwannee Horizon According to Goodyear (personal communication, 1996; Goodyear et al. 1983.46), the evidence for a true Dalton Horizon in Florida is limited and may have been restricted to the more northerly regions of the Southeastern United States. Another complicating factor in identifying a Dalton Horizon in Florida is the unsettled temporal placement of the small, lanceolate-shaped projectile points, such as the Tallahassee, Beaver Lake, and Sante Fe, that traditionally have been assigned to the Dalton Horizon based on stylistic and technological grounds (cf. Bullen 1975:45-47; Milanich 1994:53, 55). Stratigraphic data associating these hafted bifaces with a late Paleoindian time frame in Florida are lacking. In fact, the stratigraphic data that are available indicate that some of these projectile points may actually date to the late Archaic or early Woodland periods (e.g., Austin 1995; Austin et al. 1992; Estabrook 1995; Mikell 1997; Steinen 1982). Therefore, in south Florida, the Paleoindian Suwannee Horizon is succeeded by the Archaic Tradition.

The beginning of the Archaic Tradition corresponds with the onset of the Holocene and the extinction of the Pleistocene animals that formed part of the Paleoindian diet. In conventional chronological schemes, the Archaic is divided into three periods: Early, Middle, and Late (Milanich 1994; Milanich and Fairbanks 1980). The marker for the early Archaic is the side-notched Bolen projectile point which is related to the Big Sandy Horizon of the Southeastern United States (Anderson et al. 1996; Tuck 1974). Diagnostic elements of the middle Archaic in Florida are the use of large, broad-bladed, stemmed bifaces (Bullen 1975:31-32; Milanich 1994:64-66, 76-77, 99; Purdy 1981:32-35, Purdy and Beach 1980) which were used for a number of different functions, the use of the atlatl, and, particularly in south Florida, the burial of the dead in shallow ponds. Bone, shell, and antler also were used for a variety of tools and implements. The late Archaic is traditionally marked by the inception of the earliest pottery which was tempered with plant fibers (Bullen 1972, Griffin 1952:323-324; Milanich 1994:86).

Subsistence data are lacking for much of the early-middle Archaic periods, particularly for interior sites on sand ridges where faunal preservation is poor. An emphasis on a wide range of faunal and floral resources for food is assumed based on the animal and plant remains identified at the Windover site in conjunction with stable-isotope analysis (Doran and Dickel 1988a:Table 5; Tuross et al. 1994). Freshwater shellfish along with terrestrial and aquatic vertebrate faunal remains have been recovered from preceramic components at several middens in the St. Johns River region (Bullen and Bryant 1965:Table 3; Cumbaa 1976; Neill et al. 1956), and from the Myakkahatchee site in Sarasota County (Luer et al. 1987:Table 1). Unfortunately, most of these data consist of species lists with minimal quantification. The best faunal subsistence data come from Russo's analyses of faunal samples from preceramic components at sites on the Gulf coast (Russo 1987, 1991) and in the St. Johns River region (Russo et al. 1992). Archaeobotanical data from Windover, Hontoon Island, Groves' Orange Midden, and preceramic levels at sites in the upper St. Johns River basin indicate an emphasis on the collection of prickly pear cactus, grape, palm, and other wild fruits (Tuross et al. 1994, Newsom 1985, 1987, 1994).

The conventional interpretation of the Archaic settlement pattern has been one of reduced mobility in response to a more mesic environment, with social groups practicing a seasonal pattern of congregation and dispersal (Milanich 1994:78-79; Milanich and Fairbanks 1980:57, 61, 150). Recent research (Austin 1996b; Chance 1983a, 1983b; Daniel 1985, Russo 1991; Russo and Ste. Claire 1992; Russo et al. 1992; Ste. Claire 1990) has cast doubt on this interpretation. What appears to be the case is that the Archaic Tradition encompassed great variability with regard to settlement and subsistence patterns, in part because of the long time span that was involved, but also because of the wide range of environments that were being exploited by Archaic peoples requiring different adaptive strategies to be practiced in different regions of the state. This variability also appears in Archaic cultures throughout the rest of the southeastern U.S. (cf. Anderson and Hanson 1988, Chapman 1985; Russo 1994a, 1994b;

Sassaman and Anderson 1996, Smith 1986:21-27; Wesler 1985). Willey's (1966:60) description of the Archaic Tradition is relevant here: "The archaeological elements or traits which pertain to the Archaic tradition reflect a variety of regional adaptations to the quest for food and it is more difficult to construct a general description of the tradition than it is for any of those traditions already discussed." These regional differences become most apparent during the middle and late Archaic periods, and make the extension of a single, homogeneous, Archaic Tradition to all regions of the state difficult. In fact, by the late Archaic, and perhaps as early as the middle Archaic, it is possible to see the genesis of the regional cultural differences that characterize the post-Archaic.

Bolen (Big Sandy) Horizon (10,000-9000 B.P.). Widmer (1988:62-65) divides the Early Archaic period in south Florida into three horizons: Big Sandy, Kirk, and post-Kirk. The principal diagnostic markers for the early Archaic Bolen Horizon are side-notched projectile points such as the Bolen variants and the Greenbriar (Bullen 1975:51-53). Other stone artifacts associated with this horizon include end scrapers, side scrapers, Edgefield Scrapers, Waller knives, spokeshaves with graver spurs, and adzes (Purdy 1981:26-32). In Florida, the Bolen Horizon is often assigned to the late Paleoindian Tradition (e.g., Dunbar et al. 1988, Milanich 1994:53-58; Purdy 1981:24-25; Purdy and Beach 1980:114-115). Yet this assignment is at variance with the rest of the southeastern United States where side-notched points are universally assigned to the Big Sandy Horizon of the early Archaic Tradition (e.g., Anderson et al. 1996:15, Figure 1.2; Bense 1994:64-67; Goodyear 1982; Goodyear et al. 1993:27; Tuck 1974; Walthall 1980:49-52).

While it is difficult to discern the rationale for such an assignment in Florida, it appears to be based on similarities in technology, tool kit composition, settlement patterns, and, more recently, radiocarbon dates. Widmer discusses the unsettled cultural/temporal affiliation of side-notched Bolen points. While he assigns them to the Big Sandy Horizon of the greater southeastern U.S. (Widmer 1988:62), he acknowledges the fact that radiocarbon dates associated with the preceding late

Paleoindian period (Dalton Horizon in Widmer's scheme) in south Florida overlap the dates associated with Big Sandy elsewhere in the Southeast (Widmer 1988:63). Widmer (1988:63) concludes that "...it appears that it is difficult to accurately separate a distinct Big Sandy from a Dalton temporal unit...Dates on cultural material clearly span the suggested time range of both horizons...Thus, the discussion of the Late Paleoindian period by default should include the Big Sandy Horizon of the initial Early Archaic."

Goodyear (1982) has argued that excavations at disturbed cave and rockshelter sites throughout the southeastern U.S. have resulted in an erroneous association of side-notched projectile points with the Dalton Horizon which, according to Goodyear, ranged from 10,500 to 9900 B.P. He assigns side-notched points to the early Archaic period and a 10,000-9000 B.P. time frame.

Dunbar and Waller (1983:18) have suggested that Pleistocene fauna such as mammoth, horse, and giant land tortoise survived long enough to be hunted by people using side-notched projectile points. However, the studies they cite in support of this assertion present questionable associations between Pleistocene fauna and side-notched projectile points (e.g., Cockrell and Murphy 1978:1-12; Connert 1932:516; Neill 1953:170-171). Other possible evidence for the late survival of Pleistocene fauna comes from Devil's Den in north Florida where Martin and Webb (1974) suggest that some Pleistocene species, including ground sloth, dire wolf, horse, mastodon, and extinct peccary, may have existed until as late as 8000 B.P. However, their temporal assignment is based not on chronometric dates, but on an interpretation of the geological strata in a sinkhole where noncontemporaneous animals may have fallen over time creating a mixed assemblage (cf. Martin and Webb 1974:114, 135). Finally, Dunbar's carefully controlled, stratigraphic excavation at the Page/Ladson site in the Aucilla River has yet to identify such an association, all of the fauna associated with the Bolen Horizon are modern species (Dunbar et al. 1988).

There is no question that the Bolen Horizon technology and settlement pattern is more similar to those of the Suwannee Horizon than the later, middle Archaic horizons. Watts's (1969, 1971, 1975,

1980) studies of pollen-bearing sediments in the lakes of southern Georgia and north-central and south-central Florida indicate that relatively arid conditions existed prior to 8500-8000 B.P. With a few exceptions, most Bolen Horizon sites are found in locations similar to those of the preceding Suwannee Horizon, i.e., they are concentrated in the karst terrain of central and north Florida (cf. Purdy 1981:Maps 1 and 2). Except for the presence of side-notched projectile points, the tool assemblages of the two horizons are difficult to separate, with many of the same tool forms being used in each (Purdy and Beach 1980:114-115). However, if the Paleoindian Tradition is defined as an adaptation to a late Pleistocene environment, and that of the succeeding Archaic Tradition is defined as an adaptation to a Holocene environment, the absence of any secure evidence for Pleistocene fauna in association with side-notched projectile points would seem to point towards their placement within an early Archaic context.

Evidence for an early Archaic, Bolen Horizon occupation of the study area consists of surface-collected, side-notched projectile points (Greenbriar and Bolen types) recovered by local collectors on the Lake Wales Ridge (Austin 1996b). Bolen points occasionally have been recovered in Hardee County during surveys and test excavations (Batcho and Milanich 1978:11-14, Archaeological Consultants, Inc. 1994:29, Figure 7b). Side-notched points also have been found in surface collections along the southwest coast (e.g., Hazeltine 1983). The temporal position of side-notched projectile points in Florida has only recently been well established at around 10,000-9000 B.P. Three side-notched Greenbriar projectile points were recovered from the "13 meter ledge" at Warm Mineral Springs by William Royal (Cockrell and Murphy 1978:Figure 6). Clausen et al. (1975:197-198, Figure 7) report eight radiocarbon dates from cultural deposits at this site ranging from 10,630 to 8920 B.P., and Cockrell and Murphy (1978:Figure 3) report another 16 dates from the general area of the ledge that range from about 10,500 to 8300 B.P.

Although no lithic artifacts were recovered from the late Paleoindian component at Little Salt Springs, seven radiocarbon dates were obtained that range from 10,190 to 8955 B.P. (Clausen et al. 1979:Table 1). All of the artifacts are made of normally perishable materials including several wood stakes, a socketed antler projectile point, a wooden mortar, and a possible nonreturnable boomerang (Clausen et al. 1979:611). A third important site in south Florida is the Cutler Fossil site in Dade County (Carr 1986) where a radiocarbon date of 9300 B.P. was obtained from cultural strata believed to be associated with side-notched Bolen projectile points.

These early dates for side-notched Greenbriar and Bolen projectile points are in agreement with recent radiocarbon dates from the Page/Ladson site in north Florida which indicate a date range of 10,200-9700 B.P. for Bolen points there (Dunbar et al. 1988:444, 449). Stratigraphic data from the Harney Flats site in Hillsborough County generally support a post-Suwannee Horizon placement; however, some Bolen points were found in what appear to be contemporaneous association with Suwannee points, leading Daniel and Wisenbaker (1987:33-35) to suggest that both were used by late Paleoindian peoples.

The basic lifestyle described for the Suwannee Horizon is presumed to have continued into the succeeding Bolen Horizon. The fact that many of the early side-notched points on the Lake Wales Ridge have been found beneath existing lake waters corroborates the palynological and geological data that indicate that surface water was limited in these upland lakes prior to 8500 B.P. The water supplies that did exist were probably limited to shallow ponds (Watts 1971, 1975, Watts and Hansen 1988) that may have been available only on an intermittent basis. Since side-notched projectile points have been found in submerged contexts, it seems likely that early occupation of the Ridge focused on these shallow ponds, and that any earlier sites would have been situated along their margins, well below modern lake levels.

Chert provenience data suggest a central Gulf coast origin for these early Archaic people since nearly all of the side-notched, hafted bifaces were manufactured from a type of chert (known as Type 5 or Bay Bottom) that is unique to the Tampa Bay region (Austin 1996b). Initial forays into the interior would probably have been limited with early groups remaining "tethered" to permanent water, lithic, and other resources within their home range. Eventually, as utilization of the interior became more permanent, a new cachment area would have been established and new resources would have been exploited.

Kirk Horizon (9000-8000 B.P.). Following the Bolen Horizon in south Florida is the Kirk Horizon. Again this is based on surface-collected artifacts, principally from the Lake Wales Ridge (Austin 1996b). Although no radiocarbon dates are associated with these projectile points in Florida, they are well dated elsewhere in the southeastern U.S. to between 9000 and 8000 B.P. (Broyles 1971:47, Chapman 1975:48, 1977:161-162). Excavations at Harney Flats indicate that Kirk points lie stratigraphically above the earlier side-notched and lanceolate-shaped projectile points and below the middle Archaic Newnan, Marion, and Putnam types (Daniel and Wisenbaker 1987:35-36). Other possible early Archaic projectile points from south Florida include Hardee Beveled and Sumter (Austin 1996b). The cultural-temporal position of these points is not as well established, although Bullen (1975:33, 36) and Milanich (1994:64, 66) assign them to the early Archaic based primarily on technological and stylistic attributes.

Virtually no other information about the Kirk Horizon is known because of the lack of stratigraphic excavations focusing on this horizon, making it perhaps the least known of all the prehistoric manifestations in Florida. Webb (Science Applications, Inc 1981:1116) has suggested that the disappearance of Pleistocene sources of protein may have forced early Holocene populations to the coast where both marine and terrestrial protein sources could be exploited. Subsequent inundation of these sites by a rising sea would explain the relative absence of archaeological sites from this time period. Although coastal resources may have been exploited, a major shift to the coast during this time to compensate for the disappearance of Pleistocene megafauna seems unlikely since Paleoindian groups were already exploiting a wide range of extant species, as discussed previously.

Post-Kirk Horizon (8000-7000 B.P.). Widmer (1988:64-65) proposed a post-Kirk Horizon for south Florida, based primarily on the need to bridge the gap between the preceding Kirk Horizon and the subsequent Middle Archaic period. Very little evidence exists for such a horizon in south Florida, and Widmer (1988:65) speculated that this part of the state may not have been occupied during this time. Some of the projectile points discussed above (i.e., Sumter, Hardee Beveled) may, in fact, date to this horizon, but at present the only archaeological site in Florida that can be associated firmly with a post-Kirk Horizon is the Windover site in Brevard County (Doran and Dickel 1988a, 1988b).

The Windover site is a wetland cemetery which when excavated revealed the remains of 168 individuals along with numerous perishable items such as bone pins, awls, incised tubes, shell tools and beads, an antler atlatl weight, wooden stakes, cordage, mats, and fabric. Only a few lithic artifacts were recovered from the pond, including five bifaces, three of which resemble Hamilton or Thonotosassa points (cf. Bullen 1975:38, 40; Doran and Dickel 1988a:Figure 9). Seven radiocarbon dates associated with human bone or wooden artifacts range from 8120 ± 70 B.P. to 6980 ± 80 B.P. (Doran and Dickel 1988b:367-368) placing it well within the post-Kirk Horizon.

The radiocarbon dates indicate that the interments were made over a long period of time, and suggest that the pond was used repeatedly for interments for more than a millennium. The high degree of preservation of the bodies, and the lack of any evidence for scavenging of the remains by animals, suggests that they were placed in the cemetery within a few days or even hours after death (Doran and Dickel 1988a:273). Milanich (1994:73) has indicated that the interments were placed in five or six discrete groups. If true, then it seems likely that the cemetery was not associated with a single, long-term habitation, but instead was revisited and inhabited for short periods periodically by several groups over a long time span. The presence of marine shells at the site would seem to support the hypothesis that these people moved from the coast, which at this time was much farther away from the site than it is today, to the interior on a relatively regular basis. Analysis of archaeobotanical remains from the site indicate a late summer-early fall use of the site (Tuross et al. 1994:297-298).

Newnan Horizon (7000-4000 B.P.). Beginning about 7000 B.P. there was a widespread dissemination of people across the landscape of Florida as indicated by the profusion of middle Archaic projectile-point types in virtually every area of the state, including much of south Florida (Milanich 1994:76; cf. Purdy 1981:Map 3). It is not coincidental that this population expansion corresponds with climatic and environmental changes that would eventually culminate in the so-called "climatic optimum" at about 6000-5000 B.P. Water sources were becoming more abundant, the land mass of Florida was shrinking as sea level rose, and the native population was likely becoming larger. The convergence of these factors provided the impetus to explore new territories.

It is perhaps significant that the earliest dugout canoe in Florida has been radiocarbon dated at 5140 ± 100 B.P. (Newsom and Purdy 1990:Table 1). Another hallmark of this horizon is the use of thermal alteration (Ste. Claire 1987). This technology enabled poor-quality raw material to be used for the manufacture of curated tools, principally hafted bifaces, by making the stone easier to flake. Ste. Claire (1987:206) has hypothesized that the increase in the use of thermal alteration during the middle Archaic period was related to the exploitation of new environments and the need to incorporate poorer quality materials into the technological inventory.

While rarely attempted, it is possible to identify several middle Archaic horizons in Florida. The best known is the Mt. Taylor Horizon, first defined by Goggin (1952:40-43) to refer to the pre-pottery, Archaic horizon in the St. Johns River region. A distinct, middle Archaic horizon could be defined for the southwest coast based on recent excavations at Horr's Island and Useppa Island (Milanich et al. 1984; Russo 1991). Yet a third horizon could be defined for southeast Florida where recent research indicates preceramic occupation of the eastern Everglades by as early as 5000 B.P. (e.g., Carr et al. 1984; Masson et al. 1988; Newman 1986, 1993). The Newnan Horizon refers here to the middle Archaic manifestation in Florida's central interior. It gets its name from the Newnan Lake site in Alachua County and the distinctive Newnan projectile point (Bullen 1975:31; Clausen 1964). Newnan points, and the closely related Marion points, are both common artifacts at middle Archaic sites throughout Florida. Other diagnostic hafted bifaces include Putnam and Levy points (Bullen 1975:32; Purdy 1981:32-35). There also is a noticeable decrease in the use of shaped tools other than bifaces and an increased dependence on flake tools (e.g., Austin and Ste. Claire 1982; Chance 1983a; Estabrook and Newman 1984, cf. Purdy 1981:38-39).

The horizon is well dated with five radiocarbon dates from the slough cemetery at Little Salt Springs ranging from 6830 ± 155 B P. to 5220 ± 90 B P. (Clausen et al. 1979:Table 1) and two dates of 6010 ± 150 B.P. and 5900 ± 130 B P. from Newnan Lake (Clausen et al. 1975:208). Newnan points also were found in association with burials at Tick Island in Volusia County where four radiocarbon dates ranging between 5450 ± 100 B.P. and 4935 ± 100 B.P. were obtained (Jahn and Bullen 1978:22), and at the Bay West site, a wetland cemetery in Collier County that was radiocarbon dated at 6630-6675 B P. (Beriault et al. 1981:Table 2). Other sites in south Florida that contain similarly dated components include the preceramic shell midden deposits at Useppa Island that were dated at 5625 ± 100 B.P. and 4935 ± 100 B.P. (Milanich et al. 1984:270), Horr's Island, where 15 dates ranging between 4030 ± 230 and 6070 ± 90 B.P. were obtained from preceramic deposits (McMichael 1982; Russo 1991), and the preceramic deposits at the Palmer site in Sarasota County where two radiocarbon dates of 4100 ± 125 and 4050 ± 125 were obtained (Bullen and Bullen 1976:Table 2).

In addition to these sites, important excavations have been conducted at middle Archaic sites in the Tampa Bay area and Hillsborough River basin including the Tampa Palms (Austin and Ste. Claire 1982), Diamond Dairy (Chance 1983a), Wetherington Island (Chance 1981, 1982; Chance and Misner

1984), Deerstand (Daniel 1982), 8HI450D (Daniel and Wisenbaker 1981), Ranch House (Estabrook and Newman 1984), Baker Creek (Meadows 1995), South Prong I (Welch 1983), and Crystal Beach (Wolf 1975) sites; as well as at the Lake Kanapaha (Hemmings and Kohler 1974), Senator Edwards, and CCA sites (Purdy 1975, 1981) in north-central Florida, and the Gauthier site (Carr and Jones 1981; Sigler-Lavelle 1984) on the east coast.

Within the study area, the Newnan Horizon is well documented on the Lake Wales Ridge with numerous sites recorded around the upland lake margins (Austin 1992, 1996b; Janus Research 1995b; Watson 1948). Many of these sites have been discovered by local collectors who have found diagnostic Archaic projectile points during periods of drought when lake levels are low; however, Archaic points also are found along the flanks of the ridge where seep springs emerge and provide runoff to the adjacent lowlands. The archaeological evidence for middle Archaic occupation of the Kissimmee River valley is not as abundant as it is on the ridge, but this may be due to the comparative lack of surface exposures in the valley. The disking of citrus groves on the ridge is a major factor that allows for the exposure of buried artifacts and their collection by local residents on a regular basis. Nonetheless, Archaic projectile points have been recovered from several locations in the valley (e.g., Austin 1987, 1996a; Bullen and Beilman 1973; Janus Research 1995a, 1996; Kolodgy n.d.). To the west, in the Peace River valley, several middle Archaic sites have been discovered during CRM surveys and testing projects (e.g., Archaeological Consultants, Inc. 1994; Austin 1990; Bellomo 1993; Janus Research 1994b, 1995b; Wood 1976).

Only a few sites in the study area that are assignable to the Newnan Horizon have been professionally excavated, and these have been limited in scope. The Driggers #2 site on the north shore of Lake Istokpoga was tested by the author in 1993 assisted by members of the Kissimmee Valley Archaeological and Historical Conservancy (KVAHC). This site yielded three Newnan projectile points and a relatively large amount of lithic debitage. In 1994, I conducted test excavations at the Blueberry site, again assisted by members of the KVAHC. A preceramic component, represented by a single Marion projectile point and a sparse assemblage of waste flakes, was encountered underneath a dense Belle Glade midden. Preceramic lithic components also were encountered beneath Belle Glade middens along the Kissimmee River during test excavations conducted there (Austin 1996a, Austin et al. 1994). The absence of any temporally diagnostic artifacts or radiometric dates from these preceramic levels makes it difficult to assign a cultural-temporal affiliation to these components, but the earliest radiocarbon dates from the overlying middens suggest at least a pre-3000 B.P. time frame. A heavily reworked Newnan point and a sparse assemblage of lithic waste flakes were recovered from submound levels at the Air Force Mound also located along the Kissimmee River. Several heavily resharpened middle Archaic projectile points and a reworked Simpson point were surface collected from the Dragline site, a preceramic site located on the Avon Park Air Force Range near Arbuckle Creek (Austin 1987:Figure 2, Kolodgy n.d.). Test excavations conducted at this site recovered lithic waste flakes and flake tools but no temporally diagnostic bifaces (Janus Research 1994a).

In the Peace River valley, test excavations directed by the author were conducted at three preceramic sites located in northwestern Hardee County (Janus Research 1995b). The Gum Swamp 6 site closely resembles the Dragline site since it contained heavily reworked Archaic projectile points and a single Simpson point (Janus Research 1995b:63-66). Two other sites, the Horse Creek site and Horse Creek 3, also produced middle Archaic points. At the Stuart site, also in Hardee County, test excavations recovered several middle Archaic projectile points (Archaeological Consultants, Inc. 1994:46-49).

The only radiocarbon dates for the middle Archaic in this area come from the Republic Groves site, a wetland cemetery in east-central Hardee County. Three tapered wooden stakes were radiocarbon dated at 6520 ± 65 B.P., 6430 ± 80 B.P., and 5745 ± 105 B.P. (Wharton et al. 1981:78). A fourth stake returned a date of 2485 ± 80 B.P. Lithic artifacts, including several middle Archaic projectile points

(Newnan, Marion, Putnam, and Levy), were recovered from the pond and from the surface of an adjacent citrus grove (Wharton et al. 1981:64). A single test unit and several shovel tests in the grove failed to reveal any subsurface material, and the authors speculate that the upland site consisted of a small, sparse occupation or was destroyed by modern agricultural activity (Wharton et al. 1981:60).

All of the preceramic sites in the study area are similar in composition. They are characterized by low to moderate density deposits of small, non-decorticated, biface thinning and retouch flakes, occasional flake tools, and hafted bifaces which often exhibit a high degree of resharpening. Localized, non-overlapping concentrations of debitage are sometimes encountered, and often these concentrations consist of a limited range of raw-material types suggesting single-episode flintknapping activity. Furthermore, raw-material diversity among Archaic hafted bifaces is much greater than is found in preceding or succeeding assemblages (Austin 1996b) suggesting a high degree of mobility. In sum, the site structure, artifact assemblages, and overall settlement pattern suggest that Archaic occupation of the region consisted of small groups of relatively mobile hunter-gatherers with restricted access to lithic raw materials.

When the south Florida Archaic sites are compared to Archaic lithic scatters in central and north Florida, there are clear differences in terms of size, artifact content, and site structure. Archaic sites to the north are typically larger and contain many more artifacts, particularly lithic debitage (e.g., Austin and Ste. Claire 1982; Chance 1983a; Clausen 1964; Estabrook and Newman 1984; Hemmings and Kohler 1974; Meadows 1995). Milanich (1994:76-79) has characterized the central interior settlement pattern during the middle Archaic as consisting of large, "central-base settlements" and smaller, special-use sites. Tool assemblages at the larger sites are said to consist of a wide range of functional types including large wood-working tools. A more sedentary way of life is inferred (Milanich 1994:79).

These differences, and the inferred shift to a more sedentary lifestyle, may be more apparent than real. Since many of these sites are located in areas where chert outcrops are numerous, the greater number of artifacts may reflect greater access to raw materials for tool production. The greater sizes of the sites may be the result of numerous episodes of reoccupation of desirable landscapes in the interior uplands where well-drained soils and water sources often coincide with chert outcrops.

In contrast to the model of increasing sedentism through time, Daniel (1985) suggested that Archaic peoples were more mobile than their Paleoindian and early Archaic ancestors, practicing a mixed strategy of residential and logistical mobility with the former characterized by frequent residential moves which served to transport people to the resources. Daniel hypothesized that the difference between the two strategies should be evident archaeologically by the types of sites that were created and the tool assemblages associated with these sites (cf. Binford 1980, 1982). Logistical strategies should result in large residential camps occupied by the entire social unit, small, logistical camp sites occupied for short periods by special task groups, and even smaller, extractive sites such as hunting and butchering sites, quarries, plant-collecting locales, etc. Because a logistical strategy involves special task groups and requires planning, artifact assemblages should be dominated by a wide variety of tools developed especially for specific tasks. Residential sites also should contain well-defined areas that were used for functionally different activities such as living areas, work areas, communal areas, cemeteries, etc. Alternatively, foraging sites should be characterized by many, short-term residential sites possessing minimal intrasite differentiation of activity areas and a limited tool assemblage dominated by portable, multifunctional, and maintainable tools such as hafted bifaces.

One of the largest block excavations of a large, middle Archaic, "lithic scatter" site is Chance's excavation at Diamond Dairy in Hillsborough County (Chance 1983a). At this site, the tool assemblage did not contain a wide variety of functionally different, shaped tools, yet it was larger, denser, and contained more implements of varied type and function than would be expected for a special use, extractive camp. Flake tools were especially abundant, constituting the largest tool class at the site. In her interpretation of this site, Chance (1983a 72-80, 318-323; 1983b) argued that the base camp/extractive camp model may not be applicable to Florida where seasonal temperature extremes during the Archaic were not great enough to affect food resource availability dramatically, nor to require permanent, solidly constructed, protective shelters and storage facilities. Instead, she suggested a more flexible, "non-restrictive" settlement model that postulates varied uses and lengths of stay depending on specific and variable conditions. Differences in site size and artifact density are thus seen as a result of varying lengths of stay or numbers of occupations rather than functional differences (cf. Binford 1982; Ebert 1992). The archaeological assemblage resulting from such a settlement pattern would be one that conforms to neither a base camp nor an extractive camp assemblage, but instead may be a mixture of both.

In discussing Archaic settlement patterns from the perspective of Diamond Dairy, Chance concluded that

> First, it seems clear that material assemblage quantity relates best to the number of times a site was exploited, and therefore to the number, types, and consistency of the resources found there. Second, it is to be expected that, in terms of assemblage quantity, the majority of Archaic sites probably falls somewhere along a continuum between large sites containing a variety of debris, and very small minimally used sites. Finally, region-specific variables may have significantly affected, and even promoted, certain adaptive responses which are expressed within the assemblage. As a result of this last observation, a model has been generated which is based on the assumption that Archaic populations responded to peninsular Florida climatic parameters by: 1) foraging year round for a variety of resources which remained relatively constant, and

> 2) not establishing winter camps where substantial shelter and storage facilities had to be constructed to maintain population equilibrium [Chance 1983a:319-320].

The settlement pattern models of Daniel and Chance are much different from the model of Archaic settlement proposed for both the east and west coasts of Florida where permanent or semi-permanent habitation is strongly indicated. For example, seasonality studies of faunal remains from pre-ceramic levels of shell middens on the east coast suggest that Archaic peoples occupied the coast during both the summer and winter months, and some may have lived there year round (Hale 1984a, Russo and Ste. Claire 1992). Analysis of faunal remains from sites along the St. Johns River also suggest that exploitation of this habitat occurred during all seasons of the year (Russo et al. 1992). On the southwest coast, a large, apparently permanent, preceramic Archaic habitation occurred at Horr's Island with abundant evidence of structures and mound construction (Russo 1991). Analysis of shellfish growth patterns indicates year-round occupation of the site. Although lithic artifacts were rare, the site contained a large and diverse assemblage of shell and bone tools that were used in functionally specific tasks associated with fishing, wood working, bone working, and maintenance activities. In terms of site structure and artifact assemblage composition, as well as seasonal indicators in the faunal assemblage, Horr's Island conforms to a residential habitation within a logistical settlement system.

The critical factors that appear to encourage a sedentary way of life are the availability of abundant and dependable food resources (Kelly 1995; Yesner 1980). Coastal areas and some riverine habitats (e.g., the St. Johns River) offered an abundance of aquatic resources that could support full or part-time sedentism. However, in some parts of interior Florida, resources were more dispersed, less abundant, less dependable, and themselves mobile (e.g., deer). Given this type of resource base, we might expect a less sedentary way of life with smaller groups of people moving frequently. Furthermore, with the increasing availability of surface water after 8500 B.P., there would be less reason for people in the interior to remain "tethered" to permanent water sources. The wider availability of surface water, and associated faunal and floral resources, would have promoted the movement of small groups on a relatively consistent basis much as is seen among many hunter-gatherers today (e.g., Clastres 1972; Lee 1979:103-104; Tindale 1974:11, 18, 72-73; Woodburn 1972; Yellen 1976).

Late Archaic, or Orange, Horizon (4000-3000 B.P.). This horizon is differentiated from the earlier, Newnan Horizon, by the presence of ceramics tempered with plant fibers (Bullen 1972; Milanich and Fairbanks 1980:156). Using seriation and associated radiocarbon dates, Bullen (1972) divided the horizon into five distinct periods. The most recent of these he termed the Transitional period (Bullen 1959, 1971) and it is identified, in part, by the presence of sand-and-fiber-tempered sherds.

The identification of a true Orange Horizon in south Florida is debatable. Widmer (1988:71-73) discusses several sites in south Florida where fiber-tempered pottery has been found; however, in the Kissimmee region pure fiber-tempered components are rare. What is more common is the presence of the later, sand-and-fiber-tempered pottery in the basal levels of middens, often in association with thick St. Johns Plain or sand-tempered-plain sherds, and overlying either culturally sterile sands, or sparse scatters of lithic artifacts (Austin 1996a). On the Lake Wales Ridge, sand-and-fiber-tempered pottery has been recovered from the surface of several sites by local collectors and in a small, isolated component at the Blueberry site near Lake Placid (Austin et al. n.d.). Sand-and-fiber-tempered ceramics also were found in lower midden levels at Fisheating Creek (Goggin 1951:158) and Fort Center (Sears 1982:26). The ephemeral nature of these sand-and-fiber-tempered components, and the fact that they were soon replaced by exclusively sand-tempered ceramics, is a pattern that is consistent throughout south Florida (Widmer 1988:72-73).

According to the chronology established by Sears (1982) at Fort Center, the sand-and-fiber-tempered components in the Kissimmee region would be contemporaneous with his Period I. Sears (1982:185, 192, Table 7.1) reports a radiocarbon date of 2400 B. P (450 B.C. ± 105) for this period, but states that initial occupation of the site could have occurred as early as 3000 B.P. These dates and the associated ceramic assemblage are consistent with Bullen's late Orange or Transitional period.

I have argued elsewhere (Austin 1996a:83) that in south Florida the shift from a relatively mobile, foraging lifestyle to one that emphasized a more sedentary existence was made possible by the establishment of modern, productive wetland habitats at circa 3500 B.P. The earliest sites that can be associated firmly with the exploitation of these wetland habitats are in the eastern Everglades where several tree islands contain middens with preceramic components. Radiocarbon dates of 5120 ± 160 B.P. and 4020 ± 370 B.P. were obtained from charcoal in association with two burials at the Cheetum site in Dade County (Newman 1986:54-55). Similar dates of 4890 ± 100 B.P. and 4840 ± 210 B.P. were obtained from the Santa Maria and Taylor's Head sites (Carr et al. 1984:174-175; Masson et al. 1988:346). These dates correspond to the initial origin of Everglades peat deposits (cf., Gleason et al. 1974; McDowell et al. 1969) at ca. 5000 B.P. Other sites in southeast Florida have components that have been radiocarbon dated between 4000 and 3000 B.P. (e.g., Carr 1981; Mowers and Williams 1972). All of these middens appear to be small habitation sites, occupied by perhaps one or two families for short periods of time on a reoccurring basis.

In the study area, the earliest dated site is Pahokee Ridge on Lake Okeechobee (Gleason and Stone 1975:110; Hale 1989:48, 55-56). Radiocarbon dates on freshwater shells from the midden ranged from 4650 ± 140 to 3030 ± 100 B.P., and Hale (1989:48) suggests a date of at least 1800 B.C. (3750 B.P.) for initial occupation of the site. His faunal analysis indicates a heavy aquatic focus with small fishes dominating the sample augmented by mammals, turtles, and snakes (Hale 1989:107-115). At the Orange Hammock site, on the Kissimmee River, a radiocarbon date of 2870 ± 50 B.P. was obtained from a level containing sand-and-fiber-tempered pottery (Austin 1996a:72, Table 1). The faunal assemblage is similar to that described by Hale for Pahokee Ridge: a predominance of fish with turtles, reptiles, and mammals present in lesser amounts. Thus, as early as 3750 B.P. in the Lake Okeechobee basin, and as early as 2900 B.P. in the Kissimmee River valley, there are indications of a shift towards the exploitation of wetland habitats and the beginnings of a more sedentary lifestyle indicated by the development of dense midden deposits.

This shift in settlement and subsistence strategies implies that the Archaic lifestyle, at least as it was practiced in the interior of south-central Florida, was no longer a viable adaptation. This begs the question: what constitutes a late Archaic/Transitional period horizon in south Florida? Are the sand-and-fiber-tempered components found in south Florida really representative of an extension of the Archaic Tradition, or do they represent something completely new? The association of sand-and -fiber-tempered pottery with basal levels of middens, and the ephemeral nature of the few fiber-tempered components that have been identified in the region, suggest that the Transitional period does not exist as a terminal, late Archaic Horizon in south Florida. Instead, the presence of sand-and-fiber-tempered pottery identifies the beginning of the subsequent, post-Archaic Tradition (but see Johnson 1991:180-183, 1996 for a different view). Milanich (1994:88) also comments on the difficulty of identifying Transitional period sites, and suggests that its use be discontinued.

Belle Glade Tradition (3000-300 B.P.)

Although Gordon Willey (1949b) was the first to apply the term "Belle Glade" to the prehistoric culture that inhabited the Lake Okeechobee basin, it was William Sears who defined the various elements that comprise the Belle Glade Tradition. According to Sears (1974:347, 1982:1-3, 191), the Belle Glade culture is defined primarily by its adaptation to a savannah/marsh environment. Diagnostic elements of this lifestyle include the presence of the distinctive Belle Glade ceramic series, the presence of complex earthworks and ditches, a focus on aquatic habitats for the bulk of Belle Glade subsistence, involvement in inter and intraregional exchange, and the possible adoption of maize agriculture (Hale 1984b, 1989; Johnson 1991, 1996; Milanich 1994:279-298, Sears 1974, 1982). The most controversial of these is the practice of maize agriculture. It has been recognized only at Fort Center and is based on the presence of maize pollen in nine separate contexts, including two (human coprolites and paint found on a wooden carving) that provide indisputable evidence of its association with the prehistoric inhabitants of the site (Sears and Sears 1976; E. Sears 1982:118-129). The presence of maize at Fort Center has been an issue of controversy primarily because of Sears's claims for an early inception approximately 600-800 years before it was introduced elsewhere in the eastern U.S. (e.g., Johnson 1990; Milanich 1987; however, see Fearn and Liu 1995 for a review of early dates for maize in the southeastern United States). It has also been argued by Johnson (1991) that the soil chemistry at the site was not conducive to intensive maize agriculture, and therefore if maize was present, it was not grown in any great quantities. Following up on this, Milanich (1994:290-291) has suggested that maize may not have been a subsistence staple, but instead may have been intended for consumption by high-status individuals. A final verdict on the importance of maize, and the timing of its inception and use, awaits further research.

Sites of the Belle Glade Tradition appear to be widely distributed within the Kissimmee region. Numerous middens, mounds, earthworks, circular ditches, and borrows have been recorded throughout the Kissimmee River basin from as far north as Lake Tohopekaliga in Osceola County south to Lake Okeechobee (Austin 1987, 1992, 1996a; Johnson 1991, 1994; Hale 1984b, 1989). In addition, numerous Belle Glade sites are located around lake margins on the Lake Wales Ridge as well as near seep springs along the ridge margins (e.g., Austin 1992; Austin et al. n.d.; Griffin and Smith 1948; Janus Research 1995b).

Chronological Sequence. Using radiocarbon dates and a seriation of ceramics, Sears divided the Belle Glade occupation at Fort Center into four temporal periods. Using similar data, Austin (1996a) extended Sears's Fort Center chronology to the Kissimmee River valley. A recent revision of this chronological scheme has been presented by Johnson (1996) based, in part, on his analysis of temporal changes in earthwork types. While the addition of earthwork architecture as one of several criteria for identifying different cultural periods is a valuable addition to understanding the region's culture history, his discarding of Sears's well-documented sequence in favor of Willey's (1949b) earlier, two-part scheme seems an unnecessary step backwards. The following summarizes Sears's Belle Glade chronological sequence, and the social, political, and economic elements associated with each.

Period I at Fort Center began sometime prior to 2400 B.P. (450 B.C.), and perhaps as early as 3000 B.P. (Sears 1982:185, 192), while the data from the Kissimmee River valley indicates an early date of at least 3000 B.P. for the beginning of Period I there (Austin 1996a). Fort Center was not densely occupied at this time; however, based on the recovery of maize pollen, Sears believes that maize was being grown in circular fields drained by ditches, a technique that he believes diffused to the area from South America (Sears 1971, 1982:193-194). There is no evidence for differential treatment of the dead during this time.

Sand-and-fiber-tempered pottery is the diagnostic ceramic type found in the basal levels of middens associated with this period at Fort Center (Sears 1982:Figure 7.1), in the Kissimmee River valley (Austin 1996a:Figure 7), and on the Lake Wales Ridge (Austin 1992; Janus Research 1995b). Contact with other cultural groups in the St. Johns River region is suggested by the presence of spiculite-paste St. Johns pottery, although it should be noted that spiculite clays apparently occur in many parts of the state. Chert from the Gulf coast and north-central interior is suggestive of contact with cultural groups residing there. Period I assemblages tend to be small, often localized, and quickly replaced by a ceramic assemblage dominated by sand-tempered ceramics. The inference is that population size was small and that the shift to intensive exploitation of wetland habitats was not yet fully realized. There is some indication that the region may have experienced more arid conditions during the late Archaic and early Belle Glade periods than during the preceding middle Archaic. A slight reduction in the water levels in Lake Arbuckle at about 2430 ± 60 B.P. has been suggested based on stratigraphic interpretation (Austin 1996a:72). In the adjacent upper St. Johns River basin, Russo

(1986) has inferred lower water levels in lakes and marshes at around 1980 ± 90 B.P. based on the small sizes of the fish contained in the earliest midden deposits at the Gauthier site.

Period II, beginning at Fort Center at about A.D. 200, is represented archaeologically by the dominance of sand-tempered-plain pottery in midden deposits. Socially, it is characterized by a larger population and the appearance of distinct mortuary ceremonialism. Two structural features are associated with these ritual activities at Fort Center: a flat-topped mound (Mound B) that was used to prepare the interments, and an artificial pond which had a charnel platform built over it. The platform had large, carved wooden birds and other animals associated with it, and Sears (1982:42) hypothesized that these represent totems or religious symbols. Burials found in Mound B are interpreted by Sears (1982:155-157) to have been salvaged from the pond after the platform burned and collapsed. Items found with the dead included a number of stone and shell pendants, projectile points, and bone pins. Also found in the pond were Hopewell-like objects including platform pipes, galena, and quartz crystal pendants (Sears 1982:32-36; Steinen 1982:84, 96). A second mound (Mound A) located near the ceremonial mound-pond complex is believed to have served as a habitation mound for religious specialists who performed ritual activities and perhaps carved the wooden totems (Sears 1982:196). Midden deposits found in the pond are believed to be from the cleaning of Mound A (Sears 1982:167)

The functional distinction between Mound B and the Mound A-Pond Midden seems to be supported by the lithic data. Steinen's (1982) use-wear analysis indicates that the large, stemmed bifaces from Mound A and the pond midden were used as knives or saws All are very well made and, according to Steinen (1982:92), none appear to have been resharpened, although some display extensive wear Steinen (1982:93) believes that the absence of resharpening indicates the importance of maintaining the overall form of the implement. Considering the lack of chert in the area, such a requirement would require a constant influx of stone for implements used in rituals since no attempt was made to conserve material through the process of resharpening. Two large chipped points recovered from the pond had no use wear at all and may have functioned exclusively in a ceremonial context (Steinen 1982:92). Lithic tools from Mound B are smaller in size and many display heavily worn edges suggesting to Steinen (1982:92) that they were used as knives. Some of the projectile points from Mound B pictured in Steinen's report (1982:Figure 6.2) appear to have been heavily resharpened.

My reanalysis of the lithic artifacts from Fort Center support some of Steinen's conclusions but not others (Austin n.d.). Many of the large, stemmed bifaces from Mound A do exhibit use-wear patterns indicating that they were used to cut or saw very hard materials such as hard wood, bone, or shell. Others were used for scraping and perforating tasks. However, several specimens exhibit evidence of attempts at edge rejuvenation, although the extent of the tool maintenance efforts were not as extensive as is exhibited by the stemmed bifaces from Mound B. Only one of the two large bifaces from the charnel pond were available for study by me (Steinen 1982:Figure 6.2D, left). It displays excessive grinding of both lateral margins resulting in severe edge-rounding and obliteration of interior flake scar ridges. The grinding and edge-rounding are so severe that they have effectively rendered the implement unusable for utilitarian tasks. This biface also has been fractured by an intentional blow directed perpendicular to the center of the blade resulting in a radial fracture. These features support Steinen's contention that this biface, and probably the other large biface found in association, were intended as ritual offerings.

Further support for the presence of high-status individuals at Fort Center comes from Hale's (1984b) analysis of faunal remains which indicates a differential distribution of deer and raptorial bird remains. Higher percentages of deer bone occur in the midden deposit at the base of the charnel pond (which was the result of cleaning the nearby Mound A) and in Mound B. Mound A and the pond midden also contained an unusually high amount of unworked deer antler (Hale 1984b:177). Finally, all raptorial bird remains save one were recovered from Mound A, Mound B, or the Pond. These species are the ones most often represented in the wooden carvings associated with the charnel platform (Sears 1982:42-58) supporting Sears's claim that they were religious symbols or totems rather than food items.

Evidence for ritual ceremonialism, Hopewell connections, and status differentiation also are present at the Belle Glade site on the east side of Lake Okeechobee (Willey 1949b) and the Royce Mound near Lake Wales (Austin 1993). At Belle Glade, human skeletal remains were found in deep muck deposits that were eventually covered over with a sand mound. Preserved wooden carvings, reminiscent of those found at Fort Center, were found buried in the muck (Willey 1949b.53-59, 71); however, their association with the burials is not certain. A quartz crystal pendant, a travertine pendant, and a deer antler headdress are the only Hopewell-like artifacts recovered from the site (Willey 1949b:36, 128).

The recently excavated Royce Mound near Lake Wales (Austin 1993) contained large ceremonial bifaces manufactured from non-Florida chert, two Gulf Check Stamped ceramic vessels including a small tetrapodal pot with a basal perforation, galena, and numerous pendants made from metamorphic rock of non-Florida origin in association with fragmented human remains. This burial assemblage is strongly reminiscent of Yent complex sites in north Florida (Sears 1962; J. Milanich, personal communication, 1992), which themselves are believed to have Hopewell connections. These exotic items also indicate participation in an extensive and far-flung exchange network. Austin (1993:304-305) has suggested that the Royce Mound, along with other middle Woodland mounds in south Florida, indicate an emergence of high-status individuals who were involved in the manipulation of these trade relations to augment subsistence needs as well as reinforce their own power base (see Luer 1995 for a similar opinion). However, while midden components assignable to Sears's Period II are common along the Kissimmee River (Austin 1996a), to date there have been no Period II habitation sites recorded on the Lake Wales Ridge.

Period III at Fort Center begins at about A.D. 600-800, and according to Sears (1982:199) it represents a transition from ceremonial center to a new pattern of residential settlement that dominates during the subsequent Period IV. The Hopewell-like artifacts disappear although there are still ceramics, chert, and shell indicating economic contact with other regions of Florida. During this time there was a shift in the local production of pottery from a predominately sand-tempered plain ware to one characterized by spiculite paste, sand temper, and a cut and smoothed surface. This ceramic ware is known as Belle Glade Plain and it began to dominate the ceramic assemblage at Fort Center after about A.D. 1000 (Sears 1982:Figure 7.1, 199). Belle Glade Plain ceramics increase in abundance at middens along the Kissimmee River at about this time as well (Austin 1996a). This is the period of greatest midden accumulation in the valley, with most sites containing dense and geographically large Period III components. Widmer (1988:87) points out that Belle Glade ceramics begin to be found at other sites in south Florida at about this same time indicating a spread of Belle Glade influence. This interpretation equates the Belle Glade Tradition with a ceramic complex rather than a way of life. While the spread of Belle Glade influence to other regional culture areas may be monitored best by the spatial and temporal distribution of Belle Glade pottery, the basic Belle Glade pattern of settlement, subsistence focus, and technology identified by Sears at Fort Center was present in the Kissimmee River valley nearly 2000 years prior to the appearance of Belle Glade Plain (Austin 1996a).

Period IV, beginning about A.D. 1200-1400 at Fort Center and lasting until about A.D. 1700, was characterized there by low house mounds in the savannahs with attached linear earthworks that Sears (1982:200) believes were used to grow maize. Safety Harbor ceramics are found at Fort Center (Sears 1982:32, Table 3.1) and the Phillip Mound (Benson 1967; Karklins 1974) indicating contact with the west coast. An important addition is the presence of artifacts manufactured from European materials. These are found most often in sand burial mounds and are suggestive of the importance and high status of the individuals buried with them (e.g., Allerton et al. 1984; Branstetter 1995; Griffin and

Smith 1948, Luer 1994, Sears 1982). Of particular interest are tenoned plaques or badges (also referred to as ceremonial badges or tablets) that were often made from silver, gold, or non-local stone (Allerton et al. 1984; Luer 1994). The distribution of these badges corresponds very closely to the distribution of Belle Glade ceramics (cf. Allerton et al. 1984:Table 1; Luer 1989:Figure 11), with the Kissimmee River and Lake Okeechobee basins having the greatest number. Sears (1982:200) and others (e.g., Austin 1987:297, Goggin and Sturtevant 1964:189, 199) feel the tenoned badges, and other exotic artifacts, were symbols of rank and authority within Belle Glade and Calusa societies.

Austin (1996a) provides ceramic, chronometric, and subsistence data that indicate either greater population density or more permanent occupation of the Kissimmee River valley during Periods III and IV. A single radiocarbon date of 250 ± 50 B.P. (cal. A.D. 1640-1795) from the Air Force Mound provides the only chronometric evidence for occupation of the river valley during Period IV; however, the ceramic seriation indicates that several middens along the River, as well as sites on Lake Arbuckle, were also occupied at this time (Austin 1996a:Figure 7).

On the Lake Wales Ridge, the settlement chronology is less clear. Relatively intensive occupation of the Ridge was occurring by at least Belle Glade IV times based on excavations at the Blueberry site where a dense, buried midden was radiocarbon dated at 490 ± 70 B.P., or cal. A.D. 1410-1455 (Austin et al. n.d.). Analysis of faunal remains indicates exploitation of the lacustrine and marsh habitat of nearby Lake Istokpoga and Indian Prairie, although terrestrial species appear to constitute a greater proportion of the faunal sample than they do at sites located in the river valley and around Lake Okeechobee (Mitchell 1996). Also, an abundance of charred hickory nuts and saw palmetto berries are present throughout the midden suggesting a possible fall or winter occupation (D. Ruhl, personal communication, 1996).

The Blueberry site is located on the east flank of the Lake Wales Ridge and the principal midden component is buried beneath about 70 cm of comparatively sterile sand with abundant charcoal fragments A second, later occupation is evidenced by near-surface artifacts and faunal material, but these are not present in the same kind of density as in the earlier, buried component. Chemical and grain-size analyses of the soils at the site indicate alternating periods of area-wide fires that destabilized the landscape resulting in erosion of sand downslope from higher elevations followed by revegetation before the process repeated itself (Scudder 1995). The time frame indicated by the radiocarbon dates in the buried midden coincide with the "Little Ice Age" (Gribben 1978), and the subsequent fires and destabilization of the landscape may have been a result of local climatic changes associated with this event.

Additional evidence for Period IV occupation of the Lake Wales Ridge can be found at the Goodnow Mound (Griffin and Smith 1948) and the Phillip Mound (Benson 1967; Karklins 1974). Both of these sites contain historic artifacts including glass beads, metal pendants, tools, and ornaments, and European ceramics. Milanich (1995:68-70) has suggested that the presence of European artifacts at sites in central and south-central Florida are the result of a Spanish effort to establish missions in this area during the seventeenth century (cf. Hann 1993). Other archaeologists have suggested that these artifacts are reflective of the increasing economic and political relationship that was established by the Serrope and Mayaimi with the Calusa of the southwest coast (Austin 1987:297; Luer 1989; Marquardt 1987:107-108).

At the beginning of the sixteenth century, the historic descendants of the Belle Glade culture, the Mayaimi, may have been what Earle (1991b) has termed "simple" chiefdoms. He defines a simple chiefdom as one in which the size of the polity numbers in the low thousands, the political hierarchy contains only a single level, and there is a system of graduated ranking rather than full-fledged stratification (Earle 1991b:3). Widmer (1988:275) estimates that there were no more than 1500 people living around Lake Okeechobee in the sixteenth century; Hale's (1984b:184) estimates are slightly larger (2000-2500). To this must be added the people living in the river valley and on the Lake Wales Ridge.

Although estimates of population size are notoriously risky, it is doubtful that more than 2000-4000 people inhabited these areas if the numbers and size of sites are any indication of population density. Thus, a rough total of 3500-6500 people is estimated for the entire Lake Okeechobee/Kissimmee River area. In comparison, estimates of the Calusa population are on the order of 10,000 people (Widmer 1988:275) concentrated within an area approximately one-third the size of the greater Belle Glade area.

The circular and linear earthworks at Fort Center and elsewhere have been offered as evidence of centralized authority and political complexity among the Belle Glade groups (Hale 1984b:184). However, Fort Center represents almost 2000 years of near continuous occupation and earthworks were apparently constructed throughout this time. Similarly, there is no evidence for anything more than a "big man" type of society in the Kissimmee River and Lake Okeechobee basins prior to the sixteenth century; that is, essentially egalitarian with a few religious specialists or individuals attempting to enhance their status through the accumulation of exotic or surplus goods.

Historical accounts suggest that a more stratified situation was present after Spanish contact. While the various village caciques occupying the interior were apparently independent, one cacique, Serrope, seems to have attempted to consolidate his power and may have been perceived as posing a political threat to the Calusa (Marquardt 1988:173). Within the Calusa polity there seems to have been a degree of instability as various leaders competed with one another for political control and power (Marquardt 1987:104-110). The only archaeological evidence suggestive of political hierarchy in the Belle Glade region is at the Daughtry site in Highlands County which contains a large platform mound, a burial mound, and midden areas. Although no professional excavations have been conducted at the site, glass beads and the only known gold tenoned badge were recovered from the platform mound (Allerton et al. 1984:28; Douglas 1890). The site also is strategically located on the Kissimmee River about midway between Lake Okeechobee and Lake Kissimmee. Another large earthworks complex is located at Lake Kissimmee (Hale 1984b), however, no archaeological excavations have been conducted there. Additional earthworks of various types are scattered throughout the valley (Johnson 1991, 1994), as well as around Lake Okeechobee (Allen 1948; Carr 1975, 1985; Carr et al. 1995; Willey 1949b); however, there is no indication of political centralization at any of these sites during this late period.

It has been suggested that contact with the Spanish resulted in rapid changes to native societies that affected interpolity dynamics such that the situation observed by the Spanish were uncharacteristic of those present in prehistory. "The point is that we do not know how typical or long-lived were the hostilities, opportunism, and maneuvering observed and documented by the Spanish in the sixteenth century" (Marquardt 1986:67). Despite the impressive nature of the Belle Glade earthworks sites, the evidence for large, nucleated villages associated with these is limited. The fact that most Belle Glade settlements tend to be dispersed with a relative lack of large, nucleated villages containing monumental earthworks is supportive of the notion that there was no single, centralized authority prior to the sixteenth century.

CHAPTER 6
HYPOTHESES AND TEST IMPLICATIONS

The economic concepts presented in Chapter 2 are used to develop several hypotheses regarding the nature of technological change in south Florida lithic industries. In discussing the relevance of evolutionary theories to the study of stone tool use, Torrence states:

> Since tools are created and employed to satisfy a perceived need and to accomplish tasks which would themselves be susceptible to selective pressures, then an optimal technology would be favored and persist. These concepts are operationalized by means of the relationship between the costs of adopting a form of behavior and the resulting benefits that accrue from it [Torrence 1989b:2].

The appeal of economic models is that they provide an objective framework against which observed behavior, or their material correlates in the archaeological record, can be compared. They provide a structure to the process of inquiry and are amenable to quantification. For archaeologists these are important qualities. Furthermore, as Keene (1983:146) has stated in reference to optimization models, "...the value...is not necessarily to prove that organisms or groups optimized...the real value comes when optimization is used heuristically as a theoretical baseline against which we can compare observed behavior" In general, this is the approach that I have taken in this study. Although formal models are to be encouraged, the quantitative data necessary to operationalize these (e.g., time and energy required to acquire raw materials, produce and maintain tools, etc.) have not been collected in a consistent fashion nor with the explicit purpose of generating and testing such models. Consequently, I have used the insights gained from the application of microeconomic theories in anthropology and evolutionary ecology primarily in a heuristic fashion to generate hypotheses that can be tested with the data that are available at archaeological sites in the study region. These data are quantifiable, however, and although the hypotheses themselves are not stated in a formal, mathematical way, I have attempted to develop test implications that can be evaluated statistically.

Chapter 2 outlined several theoretical propositions regarding the economics of lithic procurement and use as well as reviewing several current (and often competing) theories regarding the expected organizational responses to the problem of raw-material scarcity. To review briefly, basic economic principles suggest that the cost of a commodity and the quantities consumed are determined by supply and demand. If demand remains constant, then supply or availability will dictate the cost or value of a resource. If supply is limited, and demand is high, then the cost of acquisition will be high and strategies will be employed to either reduce the cost of acquisition or offset these costs in some way. Similarly, if the risk of procurement failure is considered to be high, strategies will be implemented that reduce the risk of such failure. Further, since resources (i.e., time, energy, income) are limited, individuals will attempt to allocate available resources between competing needs and desires.

Strategies for Coping with Procurement Risk

In a resource-poor area, the risk of a resource shortfall becomes acute. Five strategies of risk abatement were presented. mobility, exchange, scavenging, diversification, and storage.

Mobility, or Direct Procurement, Versus Exchange

Mobility, or the movement of people from an area where the desired resources are limited to one in which the resources are more abundant, implies that an acquisition strategy of direct procurement is practiced. The type of mobility was not specified and it could entail the movement of the entire social group (i.e., residential mobility) or the movement of special tasks groups to the resource area for the express purpose of acquiring the desired resource (i.e., logistical mobility). Exchange, or indirect procurement, involves reciprocal economic, social, and political transactions between individuals and groups for the purpose of obtaining a desired resource. The use of this strategy implies that there are costs associated with the acquisition of the desired resource, as well as costs associated with acquiring or producing resources that are offered in exchange.

Since this research was not designed to address the question of mobility directly (a subject that easily could form the basis for a separate dissertation), I have chosen to develop hypotheses that are directed towards identifying whether direct or indirect procurement strategies were practiced. I assume that native peoples occupying the study area during the Archaic period practiced a strategy of residential mobility while those who occupied the study area during the post-Archaic practiced a less mobile lifestyle, occupying the same locations on at least a seasonal basis. I also assume that post-Archaic populations conducted their subsistence and other procurement activities within a more restricted territory than their Archaic period predecessors. The justifications for these assumptions are presented in Chapters 5 and 7. While these assumptions do not affect the test implications of the following hypotheses, they do enter into my interpretation of the data.

Distance-decay models. Several researchers have attempted to characterize prehistoric acquisition strategies through the use of various types of distance-decay or fall-off models (e.g., Bettinger 1982; Ericson 1977; Hodder 1974; Findlow and Bolognese 1982; Renfrew et al. 1968). This is usually done by plotting some measure of abundance of a commodity against distance from the source of supply. The assumption is that when a commodity is available at a localized source or sources, its distribution in space will decrease systematically from the area(s) of abundance to areas of scarcity (Renfrew 1977:72). Regression analysis is used to characterize different types of fall-off patterns with distance as the independent variable (X) and the measure of abundance as the dependent variable (Y). A curvilinear pattern is usually found to characterize most distance-decay relationships (Hodder and

Orton 1976:101). These often are interpreted as representing different types of exchange systems (Findlow and Bolognese 1982; Hodder 1974; Renfrew 1977), with a linear pattern sometimes interpreted as indicating direct access (e.g., Bettinger 1982; Findlow and Bolognese 1982).

Findlow and Bolognese (1982) discuss several curve-fitting models and the types of exchange systems that they are likely to represent. These models are presented in Table 4. Two types of distance-decay patterns are predicted for direct acquisition: 1) a linear pattern that indicates decreasing use of a supply zone with distance, and 2) an exponential pattern with a slope, or beta value, that approaches zero. Data that conform to this second pattern also may fit a simple linear model, but following Renfrew (1977:84), Findlow and Bolognese (1982:74) interpret an exponential distribution with a low beta value as resulting from direct access to an exceptionally large supply zone. Different types of exchange systems are characterized by curvilinear patterns that exhibit relatively steep slopes. The power function model is interpreted by Findlow and Bolognese (1982:72-73) as representing direct access procurement and down-the-line exchange. Down-the-line exchange also is indicated by an exponential model with a slope value near 1. Finally, exponential distance-decay patterns with slope values that approach 2 are interpreted as representing a variety of different indirect acquisition patterns such that the combined movement of raw materials approaches randomness (Findlow and Bolognese 1982:73).

These models can be simplified into two basic types: 1) those that display a gradual fall-off between supply zones and those areas where chert resources are not readily available, and 2) those that exhibit a more rapid fall-off. The former tend to characterize direct acquisition while the latter tend to characterize different types of indirect acquisition (Bettinger 1982; Renfrew 1977). Thus, if direct acquisition was practiced within the study area, linear or low-slope exponential fall-off patterns should be exhibited. If indirect procurement was practiced, curvilinear fall-off patterns should be present and the beta values (slopes) should be comparatively large (i.e., steep).

Table 4. Curve-fitting models used to identify different forms of direct procurement and exchange systems (after Findlow and Bolognese 1982).

Model	Form	Inferred Acquisition System
$Y = A + (BX)$	Linear	Direct access, supply-zone usage.
$Y = AX^B$	Power Function	Direct access linked to down-the-line exchange
$Y = Ae^{(BX)}$	Exponential, beta value of 2 or greater	Variety of exchange systems operating simultaneously.
	Exponential, beta value near 1	Directional, down-the-line exchange.
	Exponential, beta value near 0	Direct access, supply-zone usage; supply zone is exceptionally large.
$Y = X/(A + [BX])$	Hyperbolic	Intermediate between direct access and down-the-line exchange; may indicate intermediate stage in the development of more complex exchange system.

Additional indicators of direct and indirect acquisition. I focus on distance-decay relationships of lithic raw materials in my analysis of acquisition strategies because their use has a long and successful history in the field of geography as well as archaeology. Moreover, the use of more conventional kinds of lithic data to determine if direct or indirect procurement strategies were operative is problematic because both types of acquisition strategies can produce similar archaeological signatures (Daniel 1996:85-86; Hodder and Lane 1982:218; Meltzer 1989:26). However, the patchy nature of the lithic data from the study area coupled with the small sizes of the artifact samples from many sites, makes exclusive reliance on distance-decay models in this study a risky endeavor. Consequently, I also present test implications that rely on other types of data that can potentially provide circumstantial evidence in support of direct or indirect acquisition. The test implications that follow assume that direct procurement by prehistoric groups occupying the study area would have entailed travel and transport costs that would have required organizational responses to lessen or offset those costs. Thus, tools manufactured for extended use and lithic economizing should have been practiced.

If a deliberate, direct procurement strategy was practiced, archaeological assemblages within the study area should exhibit: 1) a high ratio of curated to expedient tools; 2) a reduction in biface size as distance from the lithic source area increases as a result of use, resharpening, breakage, and maintenance in order to extend the use lives of curated tools; 3) a debitage assemblage dominated by biface-reduction debris; 4) an absence of cortex flakes; and 5) a reduction in core size as distance to the source area increases reflecting more intensive use of the material. By definition, a casual, direct procurement strategy will take place at the source of the raw material and will be associated with activities conducted there. Since significant exposures of siliceous raw materials are nonexistent in the study area, and are present in limited quantities in the nearby Peace River valley, testing for the presence of such a strategy is difficult. However, casual use of lithic materials stockpiled at a habitation site may have been a viable strategy. If a casual, direct procurement strategy was practiced, there should be: 1) a high proportion of unprepared cores with only one or two striking platforms displaying unsystematic flake- removal patterns; 2) a high ratio of expedient to curated tools; 3) a debitage assemblage dominated by core-reduction debris; and 4) a comparatively high proportion of cortex flakes.

If indirect procurement strategies were practiced, then archaeological assemblages should exhibit: 1) a high ratio of curated to expedient tools among the raw materials acquired via exchange; 2) tools imported in a finished or near-finished form; and 3) a low ratio of debitage to tools for those raw materials imported as finished or nearly finished implements. If directed, social or prestige exchange was practiced then items acquired in such a fashion may exhibit an increase in size with distance from the source areas. If raw materials were acquired through formal exchange networks, then the geographic distribution of these materials should display concentrations at specific sites which functioned as redistribution centers, while materials obtained through direct procurement or gift exchange should display a more even distribution between sites.

Many of these implications are overlapping and not mutually exclusive to the identification of acquisition strategies, highlighting the difficulty of relying solely on lithic data to identify these strategies. They are addressed throughout the various chapters detailing analysis results and are summarized in relation to their relevance to direct and indirect procurement in Chapter 12.

Scavenging, Reuse, and Recycling

In an area of limited resource availability, scavenging of previously discarded tools and debitage should be a common strategy for procuring raw materials. When discarded tools and waste products occur at sites that are reoccupied on a relatively consistent basis, their locations are predictable and their procurement and use can be planned for. Thus, these materials constitute a resource that can be exploited in either a casual manner, while other activities are being conducted, or in a more deliberate manner, such as when broken bifaces are salvaged and refurbished for future use. This strategy is not only a useful response to procurement risk, but it also is a form of economizing since it reduces procurement costs by maximizing the use potential of raw materials.

If scavenging was practiced, there should be: 1) a high proportion of broken tools recycled into other functional forms; 2) a high incidence of stemmed bifaces manufactured from broken distal or proximal fragments; 3) a high ratio of complete to broken tools; 4) a high incidence of highly fragmented tools such as small distal fragments, stems, or small mid-sections that possess no functional utility among the broken tool assemblage; and 5) evidence of differential patination on flake-scar removals indicating use of long-discarded materials.

Diversification

Diversification involves the expansion of the resource mix by: 1) exploiting a wider range of resource types by including more low-quality or low-utility resources; 2) including more locally available materials in the resource mix; or 3) substituting different but functionally equivalent resources for those that are more costly to obtain. If diversification in the acquisition of raw materials was practiced, then archaeological assemblages should exhibit: 1) a high degree of variability in raw-material types, 2) replacement of distant lithic resources by more local resources, 3) substitution of other durable raw materials in place of more costly lithic materials.

Storage

Storage involves the stockpiling or caching of resources to guard against future shortfalls. It represents a form of temporal planning that allows for the availability of raw materials when and where they will be needed. If storage or caching of lithic materials was practiced as a means of guarding against a resource shortfall, then there should be: 1) caches of finished tools, blanks, or preforms; 2) stockpiles of raw material. If raw material was stockpiled, we should expect that a casual, expedient technology would be practiced. If true, then archaeological assemblages should exhibit the characteristics described for casual, deliberate procurement outlined above.

Strategies for Coping with Procurement Costs

Once the raw materials have been obtained, what costs are incurred in their transport and use and what strategies are implemented to cope with these? In Chapter 2 it was postulated that several cost factors might potentially affect the organizational structure of hunter-gatherer lithic assemblages. These factors include transport costs, production costs, and time stress.

Minimization of Transport Costs

Differences in transport costs will result in greater or lesser attempts to increase the portability of raw materials. The greater the cost of transport, the more effort will be made to increase portability. Another strategy for off-setting the cost of procurement and transport is to maximize returns at the source location. One measure of the economic return for stone is the number of usable tools that can be produced from the raw material. Since much of the raw material associated with tool production ends up as waste, one way to maximize returns would be to conduct much of the tool production process at the place of raw-material acquisition. Another reason for conducting early-stage reduction at the quarry site is that critical failure is more likely to occur during early stages of reduction (Callahan 1979:40, 163-164; Johnson 1979:25-28). Thus, conducting these activities near the source of raw material reduces the risk of critical failure at locations where replacement materials are not available.

If the cost of transporting lithic materials is considered to be great, and strategies are employed to minimize that cost, then sites in the study area should exhibit: 1) smaller tool size reflecting efforts to increase the portability of raw materials transported from distant locations; 2) smaller cores also reflecting portability; 3) fewer cortex flakes in the debitage assemblages indicating greater reduction of material prior to arrival at the sites; and 4) a narrow range of flake sizes dominated by small flakes reflecting greater reduction of material prior to arriving at the sites.

Economizing

Another cost-minimizing strategy is conservation or economizing. Maximizing the use of expensive raw materials offsets the cost of acquiring them. Thus, we can predict that in areas of scarce or non-existent lithic outcrops, lithic materials will be more intensively used in an effort to conserve material and maintenance of tools will occur in an effort to increase tool use-lives. If lithic economizing was practiced, archaeological assemblages in areas of few or no lithic resources should exhibit: 1) higher measures of edge rejuvenation on tools indicating more effort to conserve expensive raw materials; 2) a high ratio of retouched to unretouched tools reflecting a greater effort to conserve material by rejuvenating worn edges, 3) more intensive use of all available edges on flake tools, and 4) a low ratio of unutilized waste flakes to flake tools reflecting intensive use of all available material (debitage) for tool use.

Size-distance considerations. A potential complicating factor in using tool size as an indicator of reduced transport costs, is that the optimal strategy for hunter-gatherers who are residentially mobile and spend at least a portion of their yearly round in a chert-poor area may be to make and carry large bifacial implements so as to maximize the amount of usable material that will be available after repeated resharpening episodes (Morrow 1996). Thus, tool size may be more variable and size-reduction may be more a function of continuous tool maintenance than a response to transport costs. A second complicating factor is the effect of indirect procurement on the sizes of implements that are exchanged (Hodder and Lane 1982). There are four types of size-distance relationships that are possible given these considerations (Figure 15). The first is a monotonic drop-off in size (Figure 15a) which could result from one of two processes. Direct access to raw materials coupled with a constant rate of use and associated maintenance with distance from the source area would result in a progressive reduction in the sizes of the transported implements. This assumes, however, that: 1) all tools made at the source location are used and resharpened at a constant rate, and 2) that return trips to raw-material source locations are direct and immediate, with no use or discard of worn or exhausted tools on the return trip. This is an unlikely scenario unless sources of raw material are relatively close at hand, in which case, the size-distance relationship may not be observable archaeologically. The second process that could result in the pattern shown in Figure 15a is down-the-line exchange where a progressive reduction in size is a function of the number of individuals who use and rejuvenate implements before they reach their final destination.

A second pattern (Figure 15b) would occur if a group manufactured implements at a source location in preparation for an extended foray into a chert-poor region. Only a few of the implements would be in use at any one time enabling fresh implements to be available as the use-lives of active implements are exhausted. This strategy ensures that usable tools are available during the entire round trip. While the smallest tools might be discarded at the farthest locations, some also would be

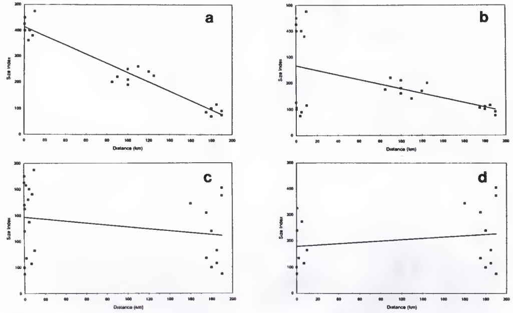


Figure 15 Hypothetical size-distance relationships resulting from different types of raw-material acquisition and use strategies: a) direct supply-zone access by mobile groups (return trip is immediate with no use or deposit of exhausted tools on the return), or down-the line exchange; b) direct supply-zone access by mobile groups in conjunction with planned use of raw materials resulting in greater variability in discarded tool sizes; c) direct supply-zone access by logistical groups or directed exchange to distribution centers; d) prestige exchange.

discarded at the source location when the group geared up for another extended trip. Intermediate locations might exhibit a range of tool sizes. The resulting size-distance relationship would resemble the one in Figure 15a, but the slope would not be as great because both large and small implements would be present at the source location.

Figure 15c exhibits very little change in the sizes of implements with distance. Hodder and Lane (1982:217-218) suggest that this pattern might occur as a result of direct access to a source area without any intermediate use. For example, trips to source locations for the express purpose of acquiring raw material and bringing it back to a habitation site might result in such a pattern. Again, however, this type of logistical procurement would most likely occur where raw materials are in reasonably close proximity to a habitation site. When distances are excessive, it is unlikely, although not impossible, that trips would be made to procure only stone. A second possible way in which the pattern in Figure 15c could occur is through directed exchange, where implements made in locations where chert is abundant are traded directly to people inhabiting a chert-poor region with no middlemen involved. If this occurred, concentrations of large implements might be found at a limited number of sites that may have served as trade and distribution centers.

The final size-distance relationship is modeled in Figure 15d which shows an increase in size with distance. This relationship reflects the acquisition of large implements that may have had prestige value. These items should occur in archaeological contexts that are conventionally interpreted as representing non-utilitarian or ritual activities such as burial mounds or cemeteries. However, prestige items also may have been used in specialized crafting activities or been reserved for tasks such as hunting that possess high symbolic meaning (cf. Helms 1993; Ingold 1987).

Minimization of Production Costs

Another way to offset the costs of acquisition is to reduce the handling costs associated with production. If strategies designed to minimize the cost of tool production were practiced, then archaeological assemblages in chert-poor areas should exhibit. 1) a high ratio of casually produced, expedient tools to formal tools; 2) a high proportion of casual, multiple-platform cores; 3) evidence of bipolar-core reduction; and 4) evidence of salvaging and recycling of discarded tools and debitage.

Reduction of Demand

If the cost of procurement is considered so great that stone is no longer used, or the need for its use is reduced as, for example, when sites are located at great distances from lithic resources, then attempts to reduce the demand for stone may be employed. Under these conditions, and if alternative sources of raw material are available, then demand can be reduced by limiting the use of lithic tools and substituting cheaper alternative raw materials. A reduction in lithic demand might be reflected by: 1) a low ratio of lithic artifacts to artifacts made from alternative raw materials reflecting substitution of other durable raw materials in place of more costly chert; and 2) a reduction in lithic artifact density as measured by the number of artifacts per cubic meter of excavated soil.

Strategies for Coping with Opportunity Costs

In her discussion of time allocation among hunter-gatherers, Torrence (1983) phrases her expectations regarding time-minimization strategies in terms of the effect that technology has on other economic spheres. Thus, she hypothesizes that among logistically organized collectors who are time stressed, more specialized tools are required to make resource extraction (i.e., subsistence procurement) more efficient by acquiring more energy in a shorter amount of time. The extra labor effort that is invested in the manufacture and maintenance of complex, specialized tools is compensated for by the speed with which energy can be extracted from the environment. For example, hunter-gatherers with a high dependence on aquatic resources which are exploited in high volume would require specialized technologies such as nets, weirs, boats, or other high-cost tools to exploit these resources efficiently. The need to process and store large quantities of subsistence items also requires specialized tools and facilities which impact on the allocation of time. Subsistence strategies that focus on highly mobile animals also should be associated with reliable, high-cost tools because the production of hunting implements cannot conflict with pursuit time once the animals have been encountered. However, time minimization also can be viewed from the perspective of technology such that the time devoted to the production and maintenance of certain tools should be minimized when the group is time stressed to allow for more time to be spent on other activities which might have a higher fitness return (Bouseman 1994:63). We might expect that the tools for which minimization of production time is a factor would be those that were not used directly in subsistence extraction, but which may have been used to manufacture such tools or facilities. Simple, low-cost tools also may have been used in tasks related to food processing where the risk of failure is less acute, or in non-subsistence-related tasks such as hide scraping, wood and bone carving, or the manufacture of ornaments. The first strategy might be considered one of "resource maximization" since technological devices that are costly to manufacture are used to increase the speed of energy extraction. The second strategy might be considered one of "time minimization" since the time spent in production and maintenance is minimized so that more time can be spent in other fitness-enhancing pursuits.

Resource maximization. If a technological strategy of resource maximization was employed to increase the speed with which certain tasks were conducted, then archaeological assemblages should exhibit: 1) high functional tool diversity; 2) limited evidence of multifunctional use of individual tools; and 3) evidence of extra labor effort in the manufacture of specialized tools that exhibit standardized form, a high degree of facial flaking, and evidence of hafting.

Time minimization. If a technological strategy of time minimization was employed to decrease the time spent in production and maintenance, and increase the amount of time available for more fitness-enhancing activities, then we should expect: 1) low functional tool diversity; 2) a high degree of multifunctional tool use; 3) a prevalence of expediently produced tools; 4) evidence of casual, expedient core reduction; and 5) limited evidence for the use of facial flaking, hafting, or other high-cost production strategies.

Summary

The above hypotheses are based on the assumption that there is a direct relationship between the cost of acquiring a resource and the organizational structure of a technology that is dependent on that resource. If the economic principles on which this assumption is based are valid, then they should be applicable to prehistoric groups that practiced either a mobile or sedentary existence. I would expect, however, that the specific strategies that were implemented would have varied depending on the types of settlement and subsistence strategies that were employed prehistorically. Table 5 provides a model for the types of strategies that might be expected for these two generalized settlement types. It should be noted that these strategies are not necessarily unique to one or the other settlement type, and in fact, some strategies may have been practiced within both types of settlement system. However, the specific means by which these strategies were operationalized may have differed. For example, diversification of resource types in response to the need to buffer against procurement risk would likely be represented among mobile groups by the diversity of lithic-resource types present in an assemblage, with both high- and low-quality materials present from a number of different source locations. Among less mobile groups, diversification may be expressed by the replacement of costly lithic materials by local materials which may be of lower quality or utility. Similarly, direct procurement could be practiced by sedentary groups; however, in the study region, direct procurement is less likely to have been a viable strategy than indirect procurement because of the distance that would have to be traveled in order to reach lithic source areas.

An interesting observation regarding the expectations of the model is that there is a wider range of variation in potential organizational strategies for sedentary groups than for mobile groups. This may

Table 5. Model of expected organizational responses for coping with the problems of procurement costs, procurement risk, and opportunity costs for mobile and sedentary populations occupying a region of limited lithic resources.

Organizational Strategies	Mobile			Sedentary		
	Procurement Risk	Procurement Costs	Opportunity Costs	Procurement Risk	Procurement Costs	Opportunity Costs
Direct Procurement	X					
Exchange				X		
Diversification	X			X		
Storage/ Caching	X			X		
Minimize Transport Costs		X			X	
Scavenging/ Recycling	X	X		X	X	
Minimize Production Cost					X	
Economizing		X			X	
Reduce Technological Demand					X	
Resource Maximization			X			
Time Minimization						X

prove to be an important criterion for identifying sedentism archaeologically. However, the degree to which any of these expectations conform to the reality of the archaeological record is the subject of the remainder of this dissertation.

CHAPTER 7
METHODS

This chapter specifies the methods that were employed to evaluate the hypotheses described in Chapter 6. Included is a discussion of the rationale for selecting the sample of sites used in the analysis as well as brief descriptions of each site. Field testing was conducted at several of these sites to obtain representative samples of artifacts and the testing procedures that were used are described. Also presented is a discussion of methods used in conducting replicative experiments that were designed to refine procedures for making technological inferences from an analysis of waste-flake assemblages, and methods related to the identification of raw materials. Finally, control variables such as cultural-temporal divisions and settlement strategies are discussed.

Database

This study required the analysis of lithic artifact assemblages from a wide range of temporal and geographic contexts within the area of study, and from archaeological sites that represent both mobile and sedentary, or semi-sedentary, adaptations. These data requirements were achieved primarily through the study of existing artifact collections including: 1) those in private collections; 2) those obtained from previously conducted archaeological research in the region; and 3) lithic assemblages housed at the Florida Museum of Natural History (FLMNH). Lithic assemblages also were obtained from limited excavations at two sites conducted specifically to obtain data for this study.

Although the geographic focus of this research is the Kissimmee region, data from sites located in adjacent areas also were included for comparative purposes. I was particularly interested in comparing lithic assemblages from sites in the study area to those from sites in chert-rich environments and to those from sites located in coastal areas where shell and sharks' teeth were available as alternative raw-material sources. A total of 32 archaeological sites comprise the sample from the primary study area with an additional 7 sites included from adjacent areas. The locations of these sites are shown in Figure 16. Table 6 provides basic descriptive data (cultural-temporal assignment, collection method, references, etc.) for each of the 39 sites. The artifact assemblages for all of these sites were analyzed by me using the methods described below.

While the sample of sites is non-random, it does represent a wide range of time periods and site types. A major limitation of the sample is the variety of collection methods employed. Some sites are represented only by artifacts collected from the surface by non-professionals. Without stratigraphic controls, inferences regarding temporal patterns at these sites are limited to an examination of temporally diagnostic tools, principally hafted bifaces. More importantly, non-temporally diagnostic artifacts from these sites, including broken bifaces, utilized flakes, cores, and debitage, could not be placed in their proper cultural-temporal contexts. Because biface implements were curated and transported from place to place, they represent a different set of depositional processes than lithic debitage or expedient flake tools. By comparing the ratios of different raw materials in the biface and debitage assemblages, it is possible to reveal important differences that can contribute to an understanding of resource procurement in the region (cf. Austin 1995a, 1995b). This can only be accomplished, however, with materials recovered under controlled conditions.

Another problem in the use of private collections is that their availability for study was sometimes limited, resulting in somewhat different types of data being recorded for different collections. For example, lithic artifacts from one collection were cemented to a canvas-backed frame and could not be removed. Therefore, data collection was limited to type identifications and raw-materials analysis. Other collections were available for study for limited periods of time, and while basic measurements

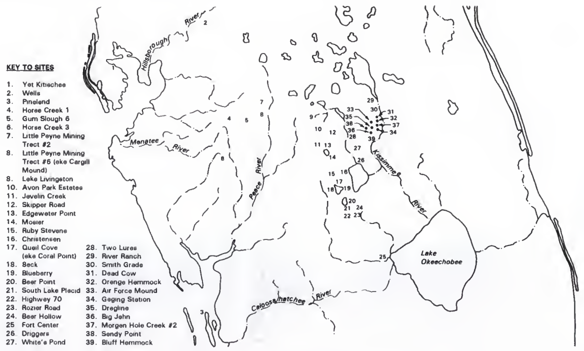


Figure 16. Locations of sites included in this study.

Table 6. Summary data on sites used in this study

Site Name	Site No.	Cultural-Temporal Affiliation	Collection Method	References[a]
Fort Center	8GL13	PA	Excavation	Sears 1982; Steinen 1982
Gaging Station	8HG18	PCA-PA[b]	Survey & Test Excavation	Austin & Piper 1986; Austin et al. 1994; Austin 1996a
Orange Hammock	8HG20	PCA-PA	Survey & Test Excavation	Austin & Piper 1986; Austin et al. 1994, Austin 1996a
Dead Cow	8HG27	PCA-PA	Survey & Test Excavation	Austin & Piper 1986; Austin et al. 1994, Austin 1996a
Air Force Mound	8HG34	PCA-PA	Test Excavation	Austin & Piper 1986; Austin et al. 1994, Austin 1996a
Dragline	8HG35	PCA	Survey & Test Excavation	Austin & Piper 1986; Janus Research 1994
Quail Cove (aka Coral Point)	8HG49	PCA	Surface Collection	Austin 1996b
Driggers #2	8HG51	PCA[c]	Survey & Test Excavation	Austin & Ballo 1987
Bluff Hammock	8HG665	PA	Test Excavation	Austin 1996a
Christensen	8HG675	PA	Test Excavation	Austin 1996b
Blueberry	8HG678	PCA-PA	Survey & Test Excavation	Austin 1996b; Austin et al. n.d.

Table 6 (Continued).

Site Name	Site No.	Cultural-Temporal Affiliation	Collection Method	References[a]
Beck	8HG679	PCA	Surface Collection	Austin 1996b
Bear Point	8HG680	PCA-PA	Surface Collection	Austin 1996b
Mosier	8HG681	PCA-PA	Surface Collection	Austin 1996b
Rozier Road	8HG682	PCA-PA	Surface Collection	Austin 1996b
South Lake Placid	8HG684	PCA-PA	Surface Collection	Austin 1996b
Morgan Hole Creek #2	8HG688	PA	Survey	Austin 1994
Avon Park Estates	8HG697	PCA	Surface Collection	Austin 1996b
Javelin Creek	8HG701	PCA	Surface Collection	Austin 1996b
Two Lures	8HG721	PCA-PA	Surface Collection	This study
Bear Hollow	8HG724	PCA	Surface Collection	Austin 1996b
Ruby Stevens	8HG739	PCA	Surface Collection	This study
White's Pond	8HG743	PCA	Surface Collection	This study
Edgewater Point	8HG764	PCA-PA	Surface Collection	Austin 1996b
Big Jahn	8HG767	PCA	Survey	Janus Research 1996a

Table 6 (Continued).

Site Name	Site No.	Cultural-Temporal Affiliation	Collection Method	References[a]
Little Payne Mining Tract #2	8HR44	PCA	Survey & Test Excavation	Bellomo 1993
Little Payne Mining Tract #6 (aka Cargill Mound)	8HR48	PA	Excavation	Bellomo 1993
Horse Creek 1	8HR68	PCA	Survey & Test Excavation	Janus Research 1995
Horse Creek 3	8HR71	PCA	Survey & Test Excavation	Janus Research 1995
Gum Slough 6	8HR92	PCA	Survey & Test Excavation	Janus Research 1995
Pineland	8LL33,36,37[d]	PA	Excavation	Austin 1995a
Yat Kitischee	8PI1753	PA	Excavation	Austin 1995b
River Ranch	8PO1685	PA	Test Excavation	Austin & Fuhrmeister 1990; Austin 1996a
Smith Grade	8PO4698	PCA	Survey	Janus Research 1996a
State Road 70	NR[e]	PCA	Surface Collection	Austin 1996b
Skipper Road	NR[e]	PA	Surface Collection	This study
Wells	NR[f]	PCA	Test Excavation	This study

Table 6 (Continued).

Site Name	Site No.	Cultural-Temporal Affiliation	Collection Method	References[a]
Sandy Point	NR[g]	PCA	Surface Collection	This study
Lake Livingston	NR[g]	PCA-PA	Surface Collection	Austin 1996b

[a] References are those in which various site data have been presented previously. Lithic data relevant to this study are presented exclusively in this volume.

[b] PCA = preceramic Archaic, PA = post-Archaic.

[c] This site had a post-Archaic component, but no lithic artifacts were recovered from it.

[d] The Pineland site complex has three site file numbers associated with it: 8LL33, 36, and 37.

[e] Not recorded on Florida Site Files; located in Highlands County.

[f] Not recorded on Florida Site Files, located in Pasco County.

[g] Not recorded on Florida Site Files; located in Polk County.

were made, raw-material identifications were not. Most collections, however, were available for extended periods of time allowing for complete analysis of all specimens.

The use of private collections was necessary, in part, because of the relative absence of controlled excavations in the study area by professional archaeologists. What these collections lack in the way of precise stratigraphic controls is compensated for by the quantity of artifacts available for study and the geographic range of sites represented in the collections. Distributional studies of projectile points in Florida and elsewhere bave demonstrated the utility of using private collections to arrive at patterns of prehistoric land use and chert procurement (e.g., Dunbar and Waller 1983; Goodyear et al. 1983; Waller and Dunbar 1977), as well as the testing of specific hypotheses (e.g., Austin 1996b; Luchterhand 1970; Sassaman et al. 1988).

To compensate for the lack of stratigraphic controls in these collections, other artifact collections recovered under controlled conditions were analyzed. Many of these were recovered during reconnaissance-level, cultural resource management (CRM) surveys and testing projects. Most of these projects were conducted or directed by me during the course of my dissertation research and, therefore, it was possible to utilize many of the methods and analysis variables specific to this study. It also was possible to have access to these materials after the projects were completed so that additional analyses could be conducted. Although the data collection at these sites was controlled, the excavations were often limited in scope and were guided by goals that differ from those which guide problem-oriented excavations. Perhaps the most important factor is that the selection of sites to excavate was not based on the goals of my research. This resulted in lithic artifact assemblages from a restricted range of temporal periods, primarily the post-Archaic, thus limiting the potential for temporal analysis using these data alone. This was another reason for including sites from outside the primary study area. Fortunately, three middle Archaic sites in the nearby Peace River valley provided an opportunity to obtain samples of lithic artifact assemblages from sites associated with this time period in an area where chert resources were known to occur but are not extensive (Janus Research 1995b). The lithic artifacts from two post-Archaic site in the Peace River valley excavated by Bellomo (1993) also were reanalyzed by me for this study.

Limited excavations were conducted at two sites within the primary study area which represent different cultural periods in order to obtain the necessary lithic collections for a temporal comparison under controlled conditions. These include the Blueberry site, located near the town of Lake Placid on the Lake Wales Ridge, and the Driggers #2 site, located on the north shore of Lake Istokpoga. The former is a multicomponent site containing evidence of middle Archaic, Belle Glade I (i.e., sand-and-fiber-tempered pottery), and Belle Glade IV occupations, while the latter is a dual component, middle Archaic and Belle Glade II(?) site. Other excavated sites with existing collections that were included in the analysis include Fort Center, a large, complex Belle Glade site located near Lake Okeechobee (Sears 1982); the Pineland site, a post-Archaic coastal habitation site on the southwest coast of Florida (Austin 1995a; Walker and Marquardt n.d.); and the Yat Kitischee site, a Manasota-Safety Harbor habitation site located on Tampa Bay (Austin 1995b).

Another reason that a large sample of sites was required is that lithic artifact assemblages in south Florida are small in comparison to those at sites located in chert-rich areas. Therefore, in order to achieve a representative sample of artifacts from different types of sites and different cultural-temporal periods, it was necessary to analyze collections from many sites.

One advantage of small lithic assemblages is that all the lithic artifacts from each site can be examined rather than a subsample, as is often the case with large assemblages. The microscopic examination of all lithic debitage enabled the identification of several flake tools exhibiting edge damage that would otherwise have been overlooked. It also enabled identification of raw- material types that occurred in minor quantities and which might not have been recognized had it been impractical to look at each and every artifact in an assemblage a sample of microdebitage; however, since this was not practiced uniformly at all sites, the artifacts recovered from the subsamples are not included in this study

Recovery methods at four sites -- Fort Center, Pineland, the Cargill Mound, and the Little Payne Mining Tract #2 site -- were not under my control. The most problematic of these is Fort Center where archaeological excavations were carried out from 1966 to 1971 by three institutions -- the University of Florida, Colgate University, and Florida Atlantic University. The main program was under the direction of William Sears. As Sears discusses in his report (1982:12), excavation methods varied depending on specific research goals. Most of the excavation was accomplished by hand using 6 in (ca. 15 cm) arbitrary levels. The standard unit size was a 5 x 5 ft square (ca. 1.5 x 1.5 m square) and excavated soil was sifted through 3/8 inch (9 5 mm) mesh hardware cloth. At Mound 5 Sears used a bulldozer to dig an exploratory trench. At Mounds A and B, he also utilized heavy equipment to dig trenches to expose stratigraphic profiles and strip large horizontal areas to look for evidence of structures or other features. The bulldozer back-bladed about 7.5-10 cm (3-4 inch) thick cuts across the mounds and these exposed surfaces were then hand-scraped with sharpened trowels. Although some of this excavated soil was moved off-mound and sifted through 9.5 mm mesh screens, some soil apparently went unscreened (Sears 1982:14). At Mound B, Sears also had to deal with a badly pot-hunted surface. The upper disturbed area was removed by excavation, presumably by hand, and sifted through 9.5 mm mesh screen.

It is clear that Sears's excavation strategy was aimed at deriving stratigraphic and spatial information; he was less interested in the contents of the mound fill. Larger artifacts such as shell tools, grinding stones, and projectile points often were recorded in situ; however, smaller artifacts such as ceramic sherds and lithic debitage with either collected as a mass sample, or were simply missed because they were too small to be detected without screening. Likewise, in those instances where screening was used, the 9.5 mm mesh size would have biased the collection against small-size artifacts.

Excavations at the Pineland site were conducted by the Florida Museum of Natural History between 1989 and 1992 under the direction of Karen Walker and William Marquardt. Recovery methods there were more consistent with those used at the excavations conducted under my direction (Walker and Marquardt n.d.). Excavation units measured 1 x 1 m square and arbitrary 10 cm levels within observable stratigraphic zones were used to maintain vertical control. All excavated soil was sifted through 6.4 mm mesh hardware cloth. Several backhoe trenches were excavated to observe subsurface strata in various parts of the site. The spoil from these trenches was not screened, but some lithic artifacts were retrieved.

The excavations at the Cargill Mound and Little Payne Mining Tract #2 were conducted by Janus Research and were directed by Randy Bellomo. His field methods were similar to mine. Shovel tests were used to delineate site boundaries and excavation was conducted by 10 cm levels with all excavated soil sifted through 6.4 mm screens. Excavation units varied in size from 1 x 1 m to 2 x 2 m square.

Control Variables

It was necessary to consider two major control variables before analysis could proceed. These included the cultural-temporal affiliations of the sites, or site components, represented by the study collections and the settlement strategies practiced by the inhabitants of the sites.

Cultural-Temporal Affiliation

The determination of cultural-temporal affiliation was accomplished through radiocarbon dating, when available, and by cross-dating of temporally diagnostic artifacts (ceramics and hafted bifaces). Radiocarbon dates were available for many of the post-Archaic components including those at the Fort Center, Pineland, Yat Kitischee, Blueberry, Gaging Station, Orange Hammock, and Dead Cow sites. Ceramic seriations also were available for most of these sites which, in combination with radiocarbon dates, enabled finer subdivisions within each of the post-Archaic occupations. Unfortunately, the lithic assemblages associated with these temporal subdivisions often were too small to be of use in any sort of meaningful comparison. In contrast, none of the Archaic components in this study have been dated chronometrically. Instead, the presence of temporally diagnostic hafted bifaces, the absence of ceramics, and the stratigraphic relationships of these preceramic components to overlying ceramic-bearing components were used to assign a preceramic Archaic affiliation. Nor was it possible to subdivide these earlier components into finer chronological units because of an absence of observable and culturally meaningful stratigraphic zones. For these reasons, the artifact assemblages recovered from controlled excavation units were separated into one of two cultural-temporal divisions -- the preceramic Archaic and the post-Archaic.

Surface-collected assemblages and artifacts recovered from shovel tests, backhoe trenches, or other uncontrolled collection units presented special difficulties in terms of cultural-temporal assignment. In general, only temporally diagnostic hafted bifaces could be assigned to specific cultural-temporal affiliations; however, non-temporally diagnostic artifacts from shovel tests or other uncontrolled collection units were included in one of the two temporal divisions if it could be demonstrated by other means that the site(s) represented a single component (i.e., Archaic or post-Archaic).

Although these cultural-temporal divisions are coarse-grained, they do appear valid given the apparent differences in settlement strategies that were practiced during the two periods (see Chapter 5). This observation leads directly to the second major control variable -- settlement variability.

Settlement Strategies

As discussed in Chapter 5, current data indicate that during the middle to late Archaic periods, native peoples occupying south Florida's interior practiced a relatively mobile settlement strategy, while the post-Archaic was characterized by a shift to a sedentary or semi-sedentary settlement strategy. This shift has been explained as an adaptive response to the increased availability of productive wetland environments in south Florida. It has been hypothesized that the shift from a strategy of high residential mobility to one of limited mobility and reduced territorial range would have had an effect on lithic-resource procurement strategies and overall technological organization.

At this point I should explain what I mean by the terms "sedentary" and "semi-sedentary." In a comprehensive review of sedentariness and its archaeological manifestations, Rafferty (1985) provides a definition of sedentism that focuses on community permanence as opposed to family or household permanence (cf. Salzman 1980:10). According to Rafferty (1985:115), sedentary settlements are those in which part of the inhabiting population occupies the same geographic location for the entire year (cf. Hitchcock 1987:374; Rice 1975:97 cited in Rafferty 1985:115). This definition has the advantage of allowing individual members of the community, or even entire families, to leave the settlement for varying periods of time for economic, social, or ritual purposes. In contrast, mobility is defined as the frequent movement of all members of a community from one residential location to another during the course of a year (Kelly 1983:278). While these concepts are useful, they essentially describe extremes along a continuum. Ethnographic research indicates that many hunter-gatherers employ a mix of the two strategies throughout the course of a year with the degree of sedentariness or mobility varying seasonally and/or yearly in response to the availability of critical resources (Binford 1980:12; Eder 1984; Kelly 1983:279, 1995:111-160). Furthermore, hunter-gatherers who are generally considered to practice a relatively sedentary settlement strategy (e.g., Ohnuki-Tierney 1984), commonly move their place of residence periodically in response to changes in resource availability.

Rafferty (1985:128-137) also discusses some of the archaeological indicators of sedentism. In general, she argues that sedentary life is manifested archaeologically by changes in the pattern of settlement in a region and the appearance of new kinds of settlements. Central to her argument is the assumption that "some of the energy saved by settling down would be channeled into greater numbers and kinds of material goods, often accompanied by more trade and ceremonial activity" (Rafferty 1985:129). Indicators of change in settlement patterning include evidence for more substantial housing, with a preference for rectangular house plans (Binford 1990; Diehl 1990), consistent patterning in the arrangement of houses within a community (Hitchcock 1987:397; Yellen 1977:89), the presence of mounds, ceremonial areas, and communal structures, the use of storage facilities (Binford 1980:15-16; Hitchcock 1987:395-396), and the location of the habitation site in close proximity to critical environmental features such as a permanent source of water (Rafferty 1994). Special-use, extractive sites should be located farther from the habitation site (Rice 1975:115 cited in Rafferty 1985:136) and these might be expected to become less diverse (Binford 1982:20-21). In terms of artifacts, sedentary societies tend to possess material goods that are more varied, numerous, complex, and heavier than mobile societies (Oswalt 1973; Rafferty 1994; Shott 1986). A related feature is the development of deep, dark midden deposits. These factors are the result of: 1) increased time spent at a site, and so an increase in the accumulation of organic debris and material items in a single location, 2) the tendency to accumulate more and heavier possessions when people no longer have to move frequently, 3) the need to carry out the entire range of maintenance activities at a single location, and 4) the need for specialized tools to be used in task-specific activities. This last factor is directly related to Binford's (1980) ideas regarding the use of logistical planning by collectors who must organize special task groups to venture into the environment to exploit resources and return these to the habitation site (see also Woodburn 1980). Other indicators that are less certainly tied to sedentariness but are sometimes used to indicate permanent habitation are the presence of pottery (Rafferty 1994), larger site size, and the presence and differential distribution of functionally distinctive artifacts or activity areas within a site.

Clearly, many of these indicators could result from a social group occupying a location seasonally or year-round. Some of them (e.g., artifact density and variety, site size, or environmental location) could result from a mobile group briefly reoccupying a favorable location in the landscape year after year. Distinguishing between a site that was occupied year-round over a period of many years from one that was occupied seasonally over the same time span is difficult without conducting large-scale excavation and detailed analysis of seasonal indicators. However, when many indicators coalesce at a single location, it seems safe to assume that the site represents a relatively permanent habitation that was occupied for an extended period of time by a single social group, either seasonally or year-round. Thus, for the purposes of this study, I make no distinction between sites that were permanently occupied (sedentary) and those that were occupied seasonally (semi-sedentary). Organizationally, the artifact assemblages associated with sites occupied for an extended period of time should differ in structured ways from those assemblages from sites that are associated with a highly mobile settlement system and so were occupied for comparatively short periods of time (cf. Rafferty 1994).

With few exceptions, all of the post-Archaic sites examined in this study exhibit most of the indicators of sedentary life specified by Rafferty and others (Table 7). Perhaps the most obvious are the presence of deep and/or dense midden deposits, abundant pottery, and burial mounds or cemeteries. Some sites contain evidence of structures in the form of post molds (e.g., Fort Center, Pineland, and Yat Kitischee). Many of the sites located along the Kissimmee River have circular arrangements of midden "mounds" that I have suggested are related to individual household locations (Austin 1996a). Fort Center contains earthworks and a ceremonial center consisting of two mounds, a charnel pond, and an enclosing earthwork (Sears 1982). At Pineland, seasonality studies of quahog clams (Mercenaria sp.) indicate that these were being exploited year-round, and so it has been inferred that the site was a permanent habitation (Quitmyer n.d.). Although lithic assemblages tend to be small at these sites, shell, bone, and (presumably) wood were used in the manufacture of a wide range of tools and implements. These are best preserved at coastal sites (e.g., Pineland and Yat Kitischee), but numerous shell and bone tools also were recovered from Fort Center (Steinen 1982:83-90), and evidence for the use of a shell and bone technology also has been found at the Gaging Station, Dead Cow, and Blueberry sites (Austin 1996a; Austin et al. 1994; Austin et al. n.d.).

Table 7. Comparison of excavated or tested sites in the study sample utilizing Rafferty's (1985) criteria for sedentariness

Site	Cultural-Temporal Affiliation[a]	Attributes of Sedentariness								
		Site Size[b]	Proximity to Critical Resources	Post Molds[c]	Deep Midden	Mounds/ Earth-works	Cemetery	Functional Activity Areas[c]	Large Artifact Assemblage	Pottery
8GL13	PA	Large	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8HG18	PA	Large	Yes		Yes	No	No	Yes	Yes	Yes
	PCA	Large	Yes		No	No	No		No	No
8HG20	PA	Medium	Yes		Yes	No	No		Yes	Yes
	PCA	Medium	Yes		No	No	No		No	No
8HG27	PA	Medium	Yes		Yes	No	Yes		Yes	Yes
	PCA	Medium	Yes		No	No	No		No	No
8HG34	PA	Small	Yes		No	Yes	No		No	Yes
	PCA	Small	Yes		No	No	No		No	No
8HG35	PCA	Medium	Yes		No	No	No	No	No	No
8HG51	PCA[c]	Medium	Yes	No	No	No	No	No	No	No
8HG665	PA	Medium	Yes		Yes	No	No		Yes	Yes
8HG675	PA	Medium	No		Yes	No	No		Yes	Yes
8HG678	PA	Medium	Yes		Yes	Yes	No	Yes	Yes	Yes

Table 7 (Continued).

Site	Cultural-Temporal Affiliation[a]	Attributes of Sedentariness								
		Site Size[b]	Proximity to Critical Resources	Post Molds[c]	Deep Midden	Mounds/ Earth-works	Cemetery	Functional Activity Areas[c]	Large Artifact Assemblage	Pottery
	PCA	Medium	Yes		No	No	No	No	No	No
8HG776	PCA	Large	Yes		No	No	No		No	No
8HR44	PA	Medium			No	No	No		No	
8HR48	PA	Medium	Yes	No	No	Yes	Yes	Yes	No	Yes
8HR68	PCA	Medium	Yes	No	No	No	No	No	No	No
8HR71	PCA	Medium	Yes	No	No	No	No	No	No	No
8HR92	PCA	Medium	Yes	No	No	No	No	No	No	No
8LL33,36,37	PA	Large	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8PI1753	PA	Medium	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
8PO1695	PA	Medium	Yes		Yes	Yes	No		Yes	Yes
Wells	PCA	Large	Yes		No	No	No		Yes	No

[a] PA = post-Archaic; PCA = preceramic Archaic.

[b] Large = > 10 hectares; Medium = 1-10 hectares; Small = < 1 hectare.

[c] Blank entry indicates excavation or testing was not extensive enough to determine presence or absence of this criterion.

The only post-Archaic sites included in the study which do not contain abundant evidence of permanent or semi-permanent habitation are the Cargill Mound and Little Payne Mining Tract #2 in Hardee County. Although a burial mound and pottery are present at the former site, excavations there revealed no post molds or midden deposits, nor was the nonceramic artifact assemblage large or diverse (Bellomo 1993). Unfortunately, details of post-Archaic settlement in the Peace River valley are not abundant. Numerous mounds are present (Clagett 1996; Wharton and Williams 1980), but few excavations have been carried out. Small habitation sites with midden remains and features have been recorded, and two have been excavated (Piper et al. 1982; Wharton 1977), but no large habitation sites similar to those found in the Kissimmee region or along the southwest coast have been discovered, despite many large-scale surveys of phosphate mining lands. The tentative conclusion is that post-Archaic peoples in the Peace River valley may have continued to practice a relatively mobile lifestyle unlike their neighbors to the east and west. If so, then the presence of mounds alone is not a convincing indicator of sedentism.

None of the preceramic Archaic sites examined for this study contain any of the indicators discussed above. As described in Chapter 5, they are all characterized by small size, limited artifact assemblages dominated by multifunctional hafted bifaces and debris resulting from their manufacture and repair, an absence of any evidence for substantial structures, and well-defined, but functionally undifferentiated activity areas that probably represent the locations of individual, short-term encampments. At a regional scale, most preceramic sites are similar to one another in terms of the attributes just described, although short-term habitation sites have been distinguished from extractive locations on the basis of greater diversity in raw materials, functional tool classes, and technology (e.g., Janus Research 1995b).

Analysis Methods

The focus of the lithic analysis was on assemblage structure and composition rather than functional or technological analyses of individual artifacts. The analysis methods that were employed were chosen with this goal in mind. Each collection of lithic artifacts was initially sorted into one of several general classes: shaped tools, unshaped tools, cores, hammerstones, debitage, and miscellaneous items. All artifacts were examined microscopically using a Bausch and Lomb Stereo Zoom Seven binocular microscope equipped with a fiber-optics light source and 12-point-ring illuminator. Initial scans were conducted at 10-20x power with more detailed examination for use-wear and raw-material identifications conducted at 30-70x power.

Artifact Typology

Shaped tools consist of artifacts that display secondary modification of the original blank exclusive of modification caused by use. Included within this class are bifaces, unifaces, microliths, and modified flakes. Bifacially flaked implements were further divided into the following classes: hafted bifaces, other bifaces, and biface fragments. Hafted Bifaces display stem, side, corner or basal notching, or other evidence of attachment to a shaft or handle. Hafted bifaces were assigned to conventional chronological types used in Florida (e.g., Bullen 1975; Purdy 1981; Robinson 1979). Those that could not be assigned to existing types with certainty are identified by a question mark after the type designation that the specimen most resembles (e.g., Marion?).

Other Bifaces include bifacially flaked implements that exhibit no evidence of hafting. This class includes nondescript bifacial forms and manufacture products such as bifacially flaked blanks and preforms. Manufacture products are identified by a low width:thickness ratio, large, randomly oriented percussion-flake scars on the surfaces of the implement, an absence of edge refinement, and an absence of use wear. Biface Fragments include fragments of bifacial implements that cannot be placed in either of the other categories. This category consists primarily of distal fragments, stems and basal fragments, and mid-sections.

Unifaces are shaped tools with flake scars occurring primarily on one surface only. The distinction between unifaces and unifacially modified flake tools was often a judgment call and was based on the degree, uniformity, and invasiveness of the unifacial flaking. Generally, if the flaking has sufficiently altered the original flake blank to the extent that its original shape is no longer discernable, then the artifact was classified as a uniface. The Microlith category is a catchall for small (< 20 mm in length), shaped tools that have been produced through the application of steep, invasive or semi-invasive retouch to a flake blank. The retouch has modified the implement to the extent that the original shape of the flake blank is no longer discernable. Modified Flakes have had one or more flake margins retouched; however, the original shape of the blank has not been greatly altered. Unshaped tools include artifacts that display edge modification caused by use wear. These are more commonly referred to as Utilized Flakes, and are so identified in this study.

Cores are masses of material exhibiting flake scars that are the result of the removal of one or more flakes from a striking platform for use as tools or as blanks for further reduction. Striking platforms may be prepared or unprepared. Bipolar Cores are small cobbles or chert fragments that are set on an anvil and struck with a percussor. By definition, bipolar-core reduction involves the application of force from two directions: the proximal end, which receives the force of the percussor, and the distal end, which receives a force rebound from the anvil (Crabtree 1972:10-11). Sollberger and Patterson (1976, 1977) argue that "true" bipolar-core reduction occurs only when the desired goal is to intentionally use the rebound effect to create a detachment force at both ends of the core. Others (e.g., Goodyear 1993; Hayden 1980; White 1977) take a more expansive view and regard any use of an anvil support as the defining criterion of bipolar-core reduction. In this study, any core that exhibited incipient cones of force (battering marks) and/or flake removals from opposing ends was considered to have been subjected to bipolar reduction

In addition to cores, pieces of raw material that may have been intended for use as cores also were identified in two of the study collections. These consisted of nodules and small, rod-shaped fragments. Cobbles are rounded or semi-rounded pieces of chert, some of which may have achieved their shape from tumbling. Cobbles were present only in the Fort Center assemblage. Rod-shaped fragments of chert were present only in the lithic assemblage from the Yat Kitischee site. These appear to have been formed in small solution channels or narrow seams within the limestone. Cobbles and rod-shaped fragments were divided into two categories. unaltered and tested. Tested material displays one or more flake scars measuring less than 10 mm in length. Material with flakes scars measuring 10 mm or more in length were classified as cores.

Hammerstones consist of rounded or semi-rounded pieces of chert that display pitting and battering marks on their surfaces indicative of having been struck repeatedly against a hard, unyielding surface.

Debitage consists of debris resulting from the manufacture and/or repair of stone tools. This includes both flakes and angular fragments (commonly referred to as "shatter"). All debitage was classified into one of four morphological categories: complete, proximal fragment, medial-distal fragment, and nonorientable (Rozen 1984; Sullivan and Rozen 1985). Complete Flakes have an identifiable platform, dorsal and ventral surfaces, and have all their margins intact. Flakes with minor edge damage can be included as "complete" if the damage does not inhibit an accurate measurement of specimen length or width (Sullivan and Rozen 1985:759). Proximal Fragments have an identifiable platform, dorsal and ventral surfaces, but the margins are broken. Medial-Distal Fragments are flake fragments that do not possess a striking platform. Nonorientable Fragments consist of pieces of debitage that do not possess a platform nor are their dorsal and ventral surfaces discernable. This class includes angular fragments, thermal shatter, and pot-lid fragments.

With one exception, no attempt was made to identify specific flake types such as biface-thinning flakes, retouch flakes, "other" flakes, etc. The exception was the identification of flakes resulting from bipolar-core reduction. These flakes tend to exhibit a number of distinctive attributes that enable them to be separated from the larger class of debitage (Ahler 1989a:210; Boksenbaum 1980:12-13; Crabtree 1972:10; Kobayashi 1975:117). These include a shattered or pointed platform with very little observable surface area; evidence of force having been applied at opposing ends of the flake, usually in the form of distal battering and force lines that originate from the distal end; and the absence of a distinct bulb of force. Other characteristics include a polyhedral cross-section with steep lateral margins and the absence of distinct dorsal and ventral surfaces.

The Miscellaneous category is a catchall for stone artifacts or debris that do not fall within any of the previously defined classes. These items consist of small pebbles or fragments of both chert and non-chert stone.

I recognize that typologies are tools that should be developed with specific problems in mind. Therefore, a number of alternative typologies were utilized in the analysis using variables such as the presence of resharpening, evidence of recycling, raw-material types, breakage patterns, etc. These are described where necessary in the following chapters.

Analysis Variables

Maximum length, width, and thickness measurements were made for all shaped and unshaped tools, cores, and hammerstones using metric calipers. All waste flakes (debitage) were placed into one of several sequential flake-size categories by using a series of nested squares drawn on a piece of metric graph paper. The interval between square sizes was set at 5 mm. Individual flakes were assigned to a size category by placing each flake on the graph paper with its ventral surface down, and then moving the specimen into the smallest square in which the long axes of the flake would fit regardless of orientation. The use of size categories enables both length and width to be combined quickly into a single measure of flake size, and is particularly useful for graphing and comparing flake-size distributions between assemblages (Patterson 1990; see also Austin 1995a, 1995b; Estabrook and Williams 1992 for applications of this method in Florida).

In addition to size, several other attribute states were recorded for each specimen. Tool attributes included condition (broken or complete), type of fracture(s), type, placement, and invasiveness of edge wear, and presence of secondary retouch or resharpening. Debitage attributes included the presence or absence of dorsal cortex (primary, secondary, or none), the number and orientation of dorsal flake scars, the condition of the striking platform (cortex covered, flat, or faceted), the type of platform preparation exhibited (ground, trimmed, battered, or none), and exterior striking-platform angle.

Primary Decortication flakes were defined as those flakes that had at least 90 percent of their dorsal surfaces covered by a cortical rind. Secondary Decortication flakes have between 10 and 90 percent of their dorsal surfaces covered in cortex. Nondecortication flakes have less than 10 percent of their dorsal surfaces covered with cortex. Platform angle was measured with a protractor and rounded off to the nearest degree. For especially small flakes, these measurements were made under magnification with the use of a binocular microscope.

Determination of probable tool utilization was based on a microscopic examination of edge damage. The use of stone tools on materials of varying resistance results in characteristic edge-damage patterns consisting of feather-, hinge-, or step-terminated scarring, snap fractures, edge rounding, striations, and polish (Ballo 1985, 1992; Odell 1980a, 1981; Odell and Odell-Vereecken 1980; Tringham et al. 1974, Vaughn 1985). The type of damage, and its placement and orientation on a tool edge, can provide an indication of the type of material worked (hard, medium, or soft) and the mode of action employed (e.g., cutting, sawing, scraping, shaving, drilling, graving, or chopping). A polar coordinate system was used to standardize the recording of use-wear placement on all tools (Figure 17).

This study utilized low-power magnification (10x to 70x) to identify use-related damage. Odell (1980b, 1994) and others (e.g., Akoshima 1987; Ballo 1985) have demonstrated the utility of the low-power approach in a variety of archaeological contexts. The principal limitation is the difficulty in identifying specific worked materials (e.g., meat, hide, hard wood, antler, shell, etc.), although general classes of material resistance can be identified with a reasonable degree of accuracy. A related problem is a bias against the identification of working edges that have been used on soft materials with low attrition rates such as meat, hide, or plant material, particularly when the tools have experienced limited use lives or have been used for multiple functions (Shea 1992:149). Higher magnification (on the order of 400-500x power) may help to eliminate this problem, but recent research has indicated that the high-power approach has its own set of limitations including ambiguous identification of use-wear traces among researchers and the difficulty of observing well-developed polish on relatively coarse-grained materials (e.g., Richards 1988). Finally, the instrumentation and special lighting needed to conduct this type of analysis often are unavailable, and are time and cost prohibitive in many instances. Since the primary goals of my use-wear analysis were to identify whether or not a specific tool was used, the general type(s) of functional task(s) the tool was employed in (i.e., scraping, cutting, drilling, etc), and the degree of use intensity, identifying the specific materials that were worked by the tools was less of a concern than the ability to identify use-related damage of any kind.

Identification of use-related edge damage also is somewhat subjective, even among use-wear specialists (Newcomer et al. 1987). This subjectivity is particularly obvious when comparing archaeological reports where wildly different frequencies of utilized flakes are often presented in artifact summaries. The variable identification of utilized flakes in the archaeological literature made it difficult

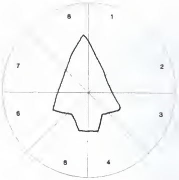


Figure 17. Polar coordinate method for describing use-wear location.

to use these data for comparative purposes. Consequently, I relied heavily (although not exclusively) on use-wear data generated by my own analysis in order to keep inter-observer bias to a minimum.

Experimental Methods

Artifact collections from many of the sites used in this study were small and consisted predominantly of lithic debitage. Therefore, a major methodological emphasis was the analysis of waste-flake assemblages for the purpose of distinguishing between different reduction strategies, specifically core reduction and patterned-tool (i.e., biface) reduction. Two important analytical techniques were employed: the Sullivan-Rozen flake typology and an analysis of flake-size distribution (see above). To increase the reliability of inferences derived from the use of these techniques, experimentally produced flake assemblages were analyzed using both the Sullivan-Rozen typology and the flake-size distribution analysis.

The experimental waste-flake assemblages used in this study were derived from three series of experiments directed and/or conducted by the author. The bulk of the debitage was derived from an experimental program conducted in 1983 under my direction. The experiments were designed to distinguish between waste-flake assemblages resulting from the production of bifacially flaked and unifacially flaked tools (Austin and Jackson 1983). The program involved two flintknappers and two raw-material types: unaltered silicified coral from the Hillsborough River Quarry Cluster and opal-rich, phosphatic chert from the Peace River Quarry Cluster (quarry clusters are defined in detail later in this chapter). A total of ten experimental replications were attempted resulting in three hafted bifaces and three unifacial scrapers. Three replications were aborted due to production failures. Since these did not result in finished implements, the debitage was not analyzed in that study.

The two flintknappers employed during the experiment possessed different degrees of skill. One had over 20 years of experience in manufacturing stone tools and could be categorized as having a high skill level. The second had approximately 2-3 years of experience and could be described as possessing a moderate level of skill. Flintknapping tools included the use of quartzite cobbles for core reduction and early-stage tool production, deer antler and hickory wood billets for late-stage thinning, and a deer antler tine for final pressure flaking of tool margins. The only exception to this was the use of a steel hammer by one flintknapper to remove large flake blanks from both the silicified coral and opal-rich chert cores.

All debitage from these experiments was collected on a sheet, bagged separately, and labeled according to experiment number and reduction stage. In addition to the waste flakes produced during tool production, debitage and waste material resulting from core reduction to produce suitable flake blanks also were collected. Each core reduction ceased when several suitable blanks were obtained. Those blanks that were subsequently used in the tool production experiments were not available for analysis during the present study, although size and weight measurements were made at the time of the original experiments. The variables used in the 1983 study included conventional attributes such as flake length, width, thickness, weight, striking-platform angle, etc The biface-, uniface-, and core-reduction flakes were subsequently reanalyzed by me for this dissertation project using the Sullivan-Rozen typology and the flake-size categories defined above.

In 1995, I conducted a second series of experiments that was designed to produce debitage resulting from the reduction of small cores for the purpose of obtaining flakes suitable for use as expedient tools. Two cores consisted of well-silicified chert obtained from an outcrop of Ocala Limestone chert near Gainesville; one consisted of a coarse-textured, fossiliferous, but well silicified, Suwannee Limestone chert from the Withlacoochee Quarry Cluster; one consisted of fine-grained Suwannee Limestone chert from the Brooksville Quarry Cluster; and a fifth core consisted of fine-textured Tampa Limestone chert from the Hillsborough River Quarry Cluster Four of the cores were reduced using free-hand percussion and a quartzite cobble hammer; one Ocala chert core was reduced by indirect percussion using a deer antler tine and a quartzite hammer. All core-reduction experiments were timed with a stopwatch. Debitage from these replications were collected and bagged in a manner similar to the 1983 experiments described above. None of the flakes produced during these core-reduction experiments was removed from the debitage assemblages.

One final assemblage of flakes is included in the present study. This assemblage is derived from the manufacture of three bifaces from unaltered silicified coral. The experimental replications were conducted by me in 1992 and utilized three flake blanks struck from a large, coral nodule using a quartzite hammerstone. Initial shaping of the blanks was accomplished using a chert hammerstone. Secondary shaping and thinning was accomplished using a deer antler billet. Two of the biface replications resulted in critical fracture (lateral snaps). The remaining blank was reduced to a roughly oval shape, with flake scars approaching and often crossing the midline of the implement. The biface approximated Callahan's (1979:37) Stage 3 form and would probably be classified as a middle- to late-stage preform by most lithic analysts. No final shaping or pressure flaking of the biface margins were conducted. The debitage from the production of all three bifaces was combined into a single assemblage. The main reason for including this flake assemblage in the analysis was to compare the debitage resulting from the production of early and middle stage biface production with the debitage assemblages resulting from the complete reduction sequence associated with finished bifacial implements.

All debitage from the three series of experiments was sifted first through fine-mesh window screen measuring approximately 1.6 mm square. In order to simulate typical archaeological collection methods, the flakes retained in the 1.6 mm screen were subsequently sifted through larger 6.4 mm hardware cloth. Basic data on initial core sizes and number of flakes produced for each of the 15 experiments are presented in Chapter 8.

Raw-Material Provenience Identification

A major element of this study was the identification of lithic raw-material provenience. A number of different techniques have been developed to identify the sources of lithic raw materials. For the most part these have been applied to rock types that are distinctive in both appearance and chemical composition, and are limited in their spatial distribution. Examples include marble, pipestone, amber, soapstone, and turquoise to name only a few (see Shotton and Hendry 1979 and Rapp 1985 for general overviews of provenience research on a variety of raw materials). Much of the early success in the sourcing of chipped-stone implements came with obsidian (e.g., Cann and Renfrew 1964, Griffin et al. 1969), a volcanic glass that is visually featureless, but has been found to be variable enough in its geochemical composition to enable accurate and consistent identification of provenience. Success has been much more difficult to attain for artifacts made from chert (or flint) because of its relatively homogenous nature and wide geographic distribution. However, as Upchurch et al. (1982a:4) point out, since most cherts are the result of limestone replacement, these replacements preserve many of the diagnostic physical and chemical properties of the host rock. If discrimination between host rocks is good, then discrimination between cherts originating in these rocks is also likely to be successful.

Potential Sources of Error in Provenience Determinations

May (1980:3-4) discusses some of the problems inherent in provenience research including the overlap of characteristic properties between different chert types, the necessity for a large and representative sample, the problem of differential exploitation of chert sources prehistorically, and the fact that not all modern chert sources were exploited in the past. Luedtke (1979:750-751) addressed these and other problems, and formally defined three types of error that can occur in provenience research. Although her discussion is directed primarily to the use of geochemical methods, some of the points she raises are applicable regardless of methodological approach.

Type 1 error. This is the assignment of an unknown specimen to a source when it actually belongs to a different source. These misassignments occur when source locations are characterized by very similar criteria; a situation that occurs often when chert sources are close to each other geographically or temporally.

Type 2 error. This error occurs when an unknown artifact is determined to be from a source not included in the study when it actually belongs to a source that was included in the study. Inadequate characterization of sources or atypical attributes in the artifact would be factors that might result in a Type 2 error. The latter could be due to leaching or weathering of the specimens, which might change or mask their diagnostic characteristics. It also could be due to cultural or technological preferences on the part of the stone worker which resulted in an archaeological assemblage that is, in effect, a subsample of the source material. This subsample may possess its own unique characteristics which are different from those that typify the source as a whole.

Type 3 error. This occurs when an unknown artifact is determined to be from a source included in the study when it is actually from a source that was not included in the study. This is most likely to occur when all sources are not known to the analyst.

Eliminating or minimizing these errors can be accomplished through adequate or representative sampling of source locations, the use of an adequate number of criteria to characterize objects and groups, the use of statistical parameters (cut-off points) that will increase or decrease the chances of unknowns being assigned to sources included in a study, or by collapsing source locations that are in close geographic proximity to one another into a single source area. However, elimination or minimization of one type of error may increase the potential for committing another type of error. For example, attempts to minimize Type 2 errors may increase the potential for a Type 3 error. This situation may be unavoidable, and determining which type of error is more critical must be determined by the analyst. This underscores the necessity of matching the appropriate methods to the goals of the research.

In this study, I believed that the greatest potential for error was likely to be a Type 1 error. This is because some source areas are better represented in the comparative type collections than others. Fortunately, the source areas closest to the study area, and therefore the ones most likely to have been exploited prehistorically by the inhabitants of the study area, are among the best sampled in the state. Moreover, the defining criteria that distinguish between these sources areas are, for the most part, unambiguous. Nonetheless, representation remains incomplete, and to guard against a Type 1 error, a conservative approach was taken to raw-material provenience identifications. This approach is discussed in more detail later in this chapter. First, it is necessary to discuss the rationale for the specific method used to identify raw-material provenience.

Characterization Methods: An Overview

There are three basic approaches to characterizing lithic materials and, hence, determining the provenience of lithic artifacts: 1) visual identification of macroscopic or microscopic attributes, 2) analysis of petrological properties, and 3) analysis of chemical composition. Each approach has its advantages and disadvantages in terms of precision, cost, and the necessity for special equipment and expertise. In this study, visual identification was used to assign artifacts to specific chert source locations. Cost, time, access to appropriate equipment, and the ability to analyze and classify all archaeological specimens were the factors that influenced this decision. In the following section I discuss the pros and cons of all three approaches, beginning first with the alternatives.

Petrographic examination. The systematic description and identification of rocks based on their petrological properties, particularly mineral content and fabric, is known as petrography. The technique used most often to accomplish this is the examination of thin-sections using a polarizing microscopic. Another technique for examining the petrological properties of lithic materials is the use of acetate peels (Young and Syms 1980). Several excellent summaries on the use of petrography in archaeology have been published including those by Clough and Wooley (1985), Shotton (1963), and Shotton and Hendry (1979).

Attempts to apply petrographic techniques to archaeological specimens have not always been successful due to the relatively homogeneous petrology of flints and cherts. Textural variation in sedimentary rocks, as compared to igneous and metamorphic rocks, tends to be relatively small and most of the successful applications of petrography in archaeology have come with stones other than chert, flint, or other siliceous materials. This has led many investigators to disregard completely the use of petrographic analysis as a serious approach to the sourcing of silicious materials. Shotton and Hendry (1979), for example, believe that flint has so few distinguishing characteristics when viewed under the microscope that petrography is of limited value for the study of flint artifacts. According to them "one thin-section of flint looks very like another," and while it may be possible to make broad generalizations based on macroscopic examination "such ascriptions are full of exceptions and all distinctions disappear in thin-section" (Shotton and Hendry 1979:77). Craddock et al. (1983:15) are even more adamant about the inappropriateness of petrographic analysis when they state that "petrological examination is useless on material as uniform and featureless as flint."

Despite these pessimistic appraisals, petrographic techniques continue to be used in the archaeological analysis of chert artifacts (e.g., Boxt and Reedy 1985; Emery 1979; Glover 1979; Glover and Lee 1984; Lavin and Prothero 1981). The technique appears to be most successful when the goal is to differentiate at a gross level between chert deposits in widely separated geographic areas. For example, Purdy and Blanchard (1973) compared thin-sections from several chert samples of both Florida and non-Florida origin. They found that the Florida cherts were broadly similar to one another but that non-Florida cherts could be differentiated from local cherts with relative ease. They concluded that petrography may not be useful for differentiating source areas within Florida, but it could be useful in determining if lithic material has been imported from sources outside of Florida.

Chemical composition. The approach used most often in the study of lithic raw-material provenience is the use of instrumental techniques to characterize the chemical composition of lithic materials and identify the source locations of unknown specimens. This approach offers the greatest precision, is quantifiable and hence susceptible to statistical methods of pattern recognition and objective tests of classification error, and is replicable by other researchers. It also tends to be expensive, requires the use of sophisticated equipment and a level of technical expertise not usually possessed by most archaeologists, may often be destructive of the artifact, and because of time and cost factors, can only be used on a few specimens.

The primary emphasis in the chemical characterization of cherts and other silicious rocks has been on trace-element composition. Trace elements are impurities that occur in silicious rock in amounts as small as a few millionths of a percent. The most popular method used to characterize siliceous materials in terms of their trace elements is neutron-activation analysis (e.g., de Bruin et al. 1972; Goad 1979; Hancock et al. 1989; Hatch and Miller 1985, Ives 1974, 1975; Julig et al. 1991;

Luedtke 1976, 1978, 1979; Mitropoulos et al. 1991; Purdy and Roessler n.d. cited in Purdy 1981:122). Other methods that have been tried include atomic-absorption spectrometry (Bush and Sieveking 1986; Craddock et al. 1983; Sieveking et al. 1970, 1972), optical-emission spectrography (Cann and Renfrew 1964; Thompson et al. 1986), X-ray florescence spectrometry (Kuhn and Lanford 1987; Nuckels 1981; Upchurch et al. 1982a), ESR spectroscopy (Maniatis and Hourmouziadi 1989), electron-microprobe analysis (Weisler 1990), nuclear gamma resonance (Mossbauer) spectroscopy (Longworth and Warren 1979), atomic absorption and flame photometry (Blackman 1974; Matiskainen et al. 1989), and particle-induced x-ray emission (Mock 1978). Still other approaches involve the use of bulk elements (Michels 1982) and thermoluminescence (Huntley and Bailey 1978), both of which bave been used to characterize obsidian. Rapp (1985) summaries much of the recent research in the field of chemical characterization. Thorough discussions of the principles and techniques of chemical characterization (as well as the problems that may be encountered) are provided in de Bruin et al. (1976), Shotton and Hendry (1979), and Sieveking et al. (1972).

The assumptions under which geochemical analysis operates have been discussed by several researchers (e.g., Bush and Sieveking 1986:137; Craddock et al. 1983:135; Luedtke 1978:414). These can be summarized as follows.

1) The lithic material at individual source locations will be relatively homogeneous in terms of its geochemical composition.
2) Variation in trace-element composition will be present between sources and this variation will be great enough to enable differentiation of lithic materials from these sources.
3) The sources of the lithic materials used to manufacture artifacts were relatively limited in number and these have all been identified and accurately characterized in terms of their geochemical composition.

4) The samples chosen for analysis are representative of the geochemical composition of the artifact(s) under study.

A review of previous work in the use of chemical characterization indicates that many of these assumptions are difficult to meet in reality. For example, the basic assumption of homogeneity within individual source locations may not be supportable. Several studies have shown that there is a high degree of chemical variability within and between formations, outcrops or source locations, and even individual samples (Aspinall and Feather 1972; de Bruin et al. 1972; Craddock et al. 1983; Luedtke 1978; Sieveking et al. 1972; Upchurch et al. 1982a). The ability to identify all possible sources may be hindered by factors such as inundation by rising sea level, over-exploitation in prehistory (particularly if a source or outcrop was relatively small), and inadequate, piecemeal, or complete absence of surveys to locate such sources. Accurate characterization of sources may be limited by the cost necessary to undertake such an extensive undertaking (Blakeman 1977:73). Few studies have been of long enough duration to enable these problems to be addressed in any systematic fashion for a particular region. An exception is the work of Sieveking and his colleagues who have, for the past 25 years, been developing methods to identify the raw-material sources of flint axes in Britain (Aspinall and Feather 1972; Bush and Sieveking 1986; Craddock et al. 1983; Sieveking et al. 1970, 1972; Thompson et al. 1986). Their published work forms a major source of information on both the prospects and problems of conducting geochemical analysis. One of the more thorough studies of trace-element analysis of cherts in the United States was conducted by Luedtke (1976, 1978, 1979, 1992). Her research is especially valuable because she focused on testing some of the assumptions on which geochemical characterization is based.

Once the source materials have been characterized, either qualitative or quantitative techniques can be used to classify samples from source locations according to their element content and identify the source locations of artifacts from archaeological sites. Just as with the use of different characterization techniques, the different classification and identification techniques vary in ease of use, precision, and assumptions. De Bruin et al. (1976:78) provide a general guideline for choosing the appropriate technique. In general, if there are large differences between the trace-element concentrations from different origins, then a simple visual comparison of the data or simple statistical manipulation may be all that is necessary (e.g., Aspinall and Feather 1972:48, Figure 1; de Bruin et al. 1976:79-81; Ferguson 1980; Sieveking et al. 1970:253). But, if the differences within objects from a source are of the same magnitude as the differences between objects from different sources, then statistical analysis is the only way to distinguish between materials from different sources. Most of the characterization studies cited above used some form of statistical analysis to reveal patterning in their data and assign unknowns to a source location. Discriminant function appears to be the statistical method of choice for classifying archaeological specimens using geochemical data, although cluster analysis also has been used (e.g., Hurtado de Mendoza and Jester 1978; Michels 1982).

Chemical characterization studies in Florida. A study by Mock (1978) was conducted on Florida cherts using proton-induced X-ray emission (PIXE) analysis. Samples were primarily from the peninsula but one sample came from the panhandle area and one from Kentucky. Florida cherts were characterized by the presence of aluminum, silicon, potassium, calcium, titanium, iron, zinc, rubidium, strontium, zirconium, and lead. Panhandle cherts contained yttrium, molybdenum, and ruthenium. The ratio of potassium to calcium appeared to follow a subregional grouping while the copper-zinc ratio appeared fairly constant throughout the peninsula. Remeasurement of three samples indicated that the results obtained through this technique were reproducible with a success rate of 80-85 percent.

Purdy and Roessler (n.d. cited in Purdy 1981:122) used neutron-activation analysis (NAA) on the same samples used by Mock (1978) for PIXE analysis. NAA identified scandium, chromium, iron, cobalt, zinc, cesium, iridium, plutonium, gold, bromium, antimony, barium, lathanium, and selenium. There was fairly close agreement between the PIXE and NAA analyses in terms of the measurement of quantities of different elements Each method was able to identify some elements that the other method was not able to do.

Nuckels (1981) and Upchurch et al. (1982a) used X-ray florescence to identify nine trace elements in samples from chert "quarry clusters" in Florida. These quarry cluster were previously identified on the basis of visual characteristics and mineralogy. The nine elements identified -- magnesium, aluminum, phosphorus, sulfur, potassium, calcium, scandium, titanium and iron -- were those that were believed to bave the greatest potential for successful discrimination based on the mineralogy of the different geological formations containing the quarry clusters. One way analysis of variance (ANOVA) was used to obtain an estimate of the level of trace-element variability within and between samples from two different quarry clusters. The results indicated that variability was significant both within and between quarry clusters. Based on this, the researchers concluded that the identified elements would not be useful for characterizing specific source locations within a quarry cluster; however, differentiating between quarry clusters might be possible (Upchurch et al. 1982a:150).

Discriminant function was then used to classify chert samples by geological formations and the probability of misclassification was calculated. Differentiation between formations was found to be only partially successful. Cherts from the upper Hawthorn Group displayed the best discrimination with only a 15 percent to 16 percent probability error. The elements that appeared to contribute most to the characterization of Hawthorn cherts were magnesium, aluminum, and phosphorus. However, Upchurch et al. (1982a:157) note that magnesium inhibits solid-state inversion from opal to quartz, a process that results in better quality chert for tool making Thus, they hypothesize that cherts chosen for tool production would tend to be low in magnesium, thereby making them more difficult to assign to their correct origin. Cherts from the Tampa Limestone Member of the Hawthorn, the Suwannee Limestone, and Crystal River Formation (Ocala Limestone) were misclassified at a much higher rate, with probability errors ranging from 27 percent to 40 percent depending on how many elements were used in the classification attempt (Upchurch et al. 1982a 160).

Visual Identification

Visual identification consists of the examination of chert samples either visually or with the use of simple and inexpensive equipment such as a hand lens or a low power (30x to 70x magnification) binocular microscope. The attributes that have been used most often to differentiate chert types include color, banding, texture, and inclusions, particularly fossil content.

The use of color to differentiate chert types is common in the archaeological literature (e.g., Ahler 1977; Deller 1989; Feder 1981; Futato 1983; Jacobson and Van Horn 1974; McGahey 1987; Ray 1982, to name just a few). In some cases, cherts from different sources possess distinctive coloration sufficient to identify them as distinct types (e.g., Futato 1983; Mitropoulos et al. 1991; Storck and von Bitter 1989). More often color variation is so great that the degree of overlap between outcrops and formations makes accurate assignment to a source impractical (Boxt and Reedy 1985:20; Holmes 1919:176; Ives 1975:22). Color in cherts also is susceptible to post-depositional change resulting from weathering, patination, and human modification by way of thermal alteration. This can cause confusion or inaccurate identification of source because the relationship between pre- and post-alteration color is not always systematic or predictable. Color may be useful if all chert sources within a region have been located and the full range of coloring is known. If used with other visual properties, successful characterization may be achieved. Used in isolation, however, the utility of color as a sourcing criterion is severely limited.

Several researchers have used fossil content to identify different chert types (e.g., Blakeman 1977, Ray 1982; Reid 1984, Upchurch et al. 1982a). As with color, however, the use of fossil content alone is usually not adequate to classify most chert types. Sieveking et al. (1972:151-152) cite several French researchers who unsuccessfully attempted to source flint using only fossil content. They felt that fossil content would tend to be uniform within a stratigraphic unit, and since this is likely to extend over a large geographic area, it would not be a very precise indicator of source location.

The best approach to the visual classification of chert appears to be the use of a suite of characteristics. Most of the researchers who have achieved any degree of success in sourcing chert or flint materials using the visual approach have done so by using color and fossil content in conjunction with other characteristics (e.g., Blakeman 1977; Goad 1979, 1984; Hammer 1976; Stallings 1989; Upchurch et al. 1982a). Although this method is rarely capable of accurately assigning chert samples to specific source locations or quarries, it is possible to assign specimens to geographic regions where exposures of chert share similar macroscopic properties. This "regional" approach to chert provenience has been used successfully by Blakeman (1977) in Alabama and by Upchurch et al. (1982a) in Florida.

Luedtke (1979:745-746) has evaluated the utility of visual identification of chert and has concluded that, despite its limitations, the method has a place in chert studies. In her own study, she was able to achieve a respectable success rate of 73.5 percent using visual identification and she noted that this might have been higher if "probable" assignments had been included as correct (Luedtke 1979:753). This opinion is echoed by Goad (1979:26) who states that "The fact that ambiguities do exist in the identification of chert does not mean that the qualitative approach should be totally abandoned. Visual attributes are often distinctive and can be utilized in forming and answering certain broad archaeological questions." Finally, the volume of lithic material that must be analyzed to make meaningful inferences regarding lithic-resource use requires that time- and cost-efficient methods of identifying chert sources be employed.

Summary

This review of previous research in raw-material provenience determinations has led to the following conclusions. The assignment of an artifact made of a particular material to a particular source depends on the characteristic attributes of that artifact falling within the range of variation for the same attributes which characterize the source, and outside the range of variation for all other sources. The procedures of classification and identification can only result in a probability of non-membership in a group rather than a probability of membership, because until all sources in an area are sampled, the possibility that the sample or artifact came from an unidentified source cannot be discounted. Even if all sources are identified, adequately sampled, and accurately characterized, it remains an unrealistic goal to expect 100 percent precision in the classification and identification of lithic sources and artifacts regardless of the method used.

This review also indicates that the ability to differentiate between source locations tends to increase at higher and higher levels of the geological hierarchy; in other words, differences between formations tend to be greater than differences between individual source locations. This is reflected in the fact that in nearly all of the studies cited above, the highest classification success rates came with chert or flint sources that were separated from one another geographically and, thus, probably had quite different geological origins making their characterizations easier. In these instances, the use of visual characteristics or petrological properties often can provide results nearly as good as those derived from more sophisticated trace-element techniques (e.g., Blakeman 1977; Luedtke 1979; Upchurch et al. 1982a).

All of this leads to a final important point. It is very difficult to assign individual artifacts to a specific source with a high degree of certainty, and over-emphasis on this type of analysis should probably be avoided (Luedtke 1979:747). On the other hand, assemblage assignments have a much greater probability of being correct because the sample under study is greater, more representative examples of the source can be expected, and the effect of individual misclassifications on the overall results of the study can be minimized.

The Quarry-Cluster Method

Based on the above review, visual identification was determined to be most appropriate for identifying raw-material provenience in this study. The specific method chosen is the quarry-cluster technique developed by Upchurch et al. (1982a). There were several reasons for choosing this approach. First, a relatively large comparative collection of chert types from all of the major chert-bearing formations was available for use. This collection covers a wide geographic range and encompasses most (although admittedly not all) of the major chert source areas in the state. It also was considered essential to examine each and every artifact in the study collections for the purpose of raw-material identification so that the hypotheses outlined in Chapter 6 could be tested adequately. Although most of the lithic assemblages were small, the time and money necessary to analyze all of the artifacts using chemical characterization would have been prohibitive. Given that the study area is located outside of the major chert-bearing regions of the state, the identification of cherts to the formation level was considered adequate to identify major patterns in the direction and distance to chert procurement areas. Interformational differences are distinctive in Florida cherts and so offer the greatest potential for successful classification of lithic assemblages. Intraformational variation is also present geographically, although some of the diagnostic criteria overlap, making identification to the next lowest level in the classification hierarchy less precise. Nonetheless, blind tests and comparisons of raw-material identification between analysts familiar with the quarry-cluster method indicated that successful classification could be achieved with a reasonable degree of accuracy and replicability. The accurate identification of general geographic regions of chert procurement was considered more important to the goals of this study than the identification of specific source locations or quarry sites which are difficult, if not impossible, to determine with a high degree of accuracy regardless of the method used.

The quarry-cluster method utilizes fossil content, rock fabric, and presence of inclusions such as quartz sand, phosphate pellets, or calcite crystals to associate an artifact with the geological formation from which the chert originated. The four major chert-bearing formations in Florida are the upper Eocene Crystal River biozone of the Ocala Limestone, the Oligocene Suwannee Limestone, the Tampa Limestone Member of the Miocene Hawthorn Group, and the silica-rich clays of the upper Hawthorn (see Chapter 4). Within these geological formations, Upchurch et al. (1982a) have identified geographic clusters of chert outcrops and prehistoric quarries which they refer to as "quarry clusters." These quarry clusters represent geographic areas where chert outcrops share similar characteristics related to their environment of deposition. The cherts that outcrop within each quarry cluster exhibit similar visual characteristics which enable archaeological specimens to be assigned to specific quarry clusters with a relatively high degree of accuracy. The specific criteria used in this study are described below.

Diagnostic Criteria.

Most of the artifacts analyzed in this study are manufactured from silica-replaced limestone (chert); however, some are made from silicified coral and a few are manufactured from dolomite, quartz, and fossilized bone. A suite of diagnostic criteria was used to assign the chert artifacts to specific quarry clusters. These included the fabric of the host rock, fossil content, the presence of secondary inclusions, color, luster, and porosity.

Rock fabric. Fabric refers to the texture and composition of the components that constitute the original carbonate rock in which the chert formed. A system of classifying carbonate rocks according to their fabric was developed by Dunham (1962) and his system is used here. In rocks where the depositional structure is observable, Dunham (1962:Table 1) distinguishes between five types of rock fabric. Mudstones, wackestones, and packstones all contain individual grains, or sedimentary components such as fossils, sand, pelletal material, etc., that are imbedded in clay or silty mud. In mudstones, less than 10 percent of the rock fabric consists of these large grains and the grains are not usually in contact with one another. Mudstones form under low-energy conditions and silicification is not common because the low permeabilities of the host rock inhibits precipitation of silica-rich waters and subsequent replacement. Wackestones are also mud-supported rocks but these contain more than 10 percent large grains. The grains generally do not come in contact with one another. Packstones are grain-supported, which means that the individual grains that compose the host rock are in contact; however, the pore spaces between the grains are filled with mud. Grain-supported rocks tend to be more permeable and many are silicified. Grainstones are grain-supported rocks that have most of the individual grains in contact with one another with minimal mud between them. They tend to be porous and highly permeable making them the most commonly silicified of the carbonate rocks in Florida because silica-rich waters can flow through them freely. In boundstones the original components of the host rock were bound together during deposition; that is, sediments were trapped during the growth of organic skeletal material. In Florida, the most common boundstone is coral. During growth of the coral, mud is trapped within the coral head resulting in permeability contrasts between the mud and the coral.

Once the host rock has been replaced with silica, the quartz may assume one of four fabrics. Phaneritic, or coarsely crystalline, fabrics include void-filling chalcedony and rock-crystal quartz, neither of which was used extensively for tool making in Florida, although occasional examples do exist. For instance, a bifacial celt made from a coral mold that was replaced with void-filling chalcedony was recovered from the Rock Hammock site in Hillsborough County (Austin and Ste. Claire 1982:147, Plate 21). Artifacts made from quartz crystals are occasionally found at Florida sites and are assumed to have been obtained via trade from areas to the north of Florida where this form of quartz is common. Aphanitic fabrics consist of quartz crystals that are too small to be seen with the naked eye. These stones were sought out by prehistoric peoples as raw materials for tool production because of their fine texture and structural homogeneity. The two major categories of aphanitic fabrics in Florida cherts are microspherulitic chalcedony and microcrystalline quartz (Nuckels 1981:21-29, Upchurch et al.

1982b:270-273). Microspherulitic chalcedony consists of small spheres of chalcedony (i.e., fibrous quartz) that are too small to be seen without the use of a polarizing microscope According to Upchurch et al. (1982a:47), microspherulitic chalcedony is common in packstones and grainstones where the pore spaces have become filled with chalcedony Microcrystalline quartz fabrics contain microscopic quartz crystals that may form during replacement, but more commonly are the result of alteration during the process of chert diagenesis (Upchurch et al. 1982b:273).

Fossil content. Another major criterion is the composition of the constituent components of the host rock, i.e., the grains themselves. In Florida limestones, the preserved remains of the organisms that contributed the calcium carbonates that formed the rock in the first place are often preserved. These organisms were sensitive to the different ecological conditions that existed at the time of deposition. As a result, different families and genera of fossils characterize the sediments that contribute to the different geological formations. This makes them especially useful for identifying cherts derived from these carbonate formations. Four major fossil groups are present in Florida cherts: foraminifera, pelecypods, corals, and charophytes. Other fossils that are useful in chert identification include gastropods and echinoids.

Foraminifera are single-celled organisms that secrete shells composed of calcium carbonate. Because they are small, they often are preserved with little breakage or deformation. They often form a major fraction of the original composition of the host rock and so are commonly used by geologists to identify and correlate limestone units world-wide Examples of some of the most common and diagnostic foraminifera in Florida are shown in Figure 18 Cushman (1948) provides illustrations and descriptions of many common foraminifera and Upchurch et al. (1982a:57-69) cite several references in the geological literature of Florida that contain excellent photographs and illustrations of diagnostic foraminifera.

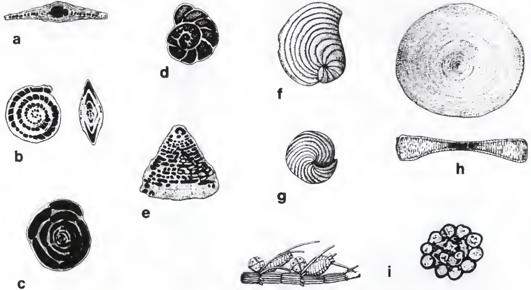


Figure 18 Examples of diagnostic fossils used in the identification of chert provenience: a) Lepidocyclina sp., Family Orbitoididae, b) Operculinoides sp, Family Orbitoididae, c) Nummoloculina sp., Family Miliolidae; d) Stensioina sp , Family Rotaliidae; e) Dictyoconus sp., Family Valvulinidae, f) Peneroplis sp., Family Peneroplidae; g) Archaias sp., Family Peneroplidae, h) Sorites sp., Family Peneroplidae; i) charophyte oogonia. Redrawn from the following sources: Cole (1945. Plates 1, 2, 5), Cushman (1948.Plates 14, 24, 52),Taylor 1981:Figure 4.6, and Upchurch et al. (1982a.Figures 16c, 19a).

The carbonate rocks of Florida contain many species of foraminifera, but only a few are diagnostic of specific formations. Furthermore, it is only necessary to be able to identify these to the family or sub-family levels. The Crystal River biozone of the Ocala Limestone can be recognized by the presence of foraminifera of the Family Orbitoididae. Identifiable species include Lepidocyclina, Operculinoides, and Nummulites. Orbitoid foraminifera are oval in shape and, when viewed in cross-section, tend to be thin with a moderate to pronounced bulge in their centers (Figure 18a-b). They can be quite large in size and are easily identified. Suwannee Limestone cherts typically contain many small fossils and fossil fragments. The most diagnostic are those species in the Family Miliolidae. Miliolids are characterized by chambered tests that coil around an elongate, central axis. The coiling occurs along a plane that shifts around the central axis as each new chamber is secreted (Figure 18c). Other fossils that occur in Suwannee Limestone cherts include the genera Rotalia (Figure 18d), Elphidium, and Dictyoconus (Figure 18e). The latter is often preserved as a hollow, V-shaped or U-shaped pit in the matrix of the chert. The overall small size of the species that comprise the Suwannee Limestone fossil assemblage, and their presence in a grainstone fabric, are major identifying criteria of cherts that are derived from this formation.

Cherts derived from the Tampa Limestone Member of the Hawthorn Group contain numerous foraminifera of which two groups of the Family Peneroplidae are diagnostic. Peneroplids are foraminifera that have chambered tests that spiral around a central axis, but unlike Miliolids, the spiral is restricted to a single plane (Figure 18e-g). Ridges that spiral out away from the center of the test are often visible. Some species are recognizable because the test uncoils slightly and flares out at the end. The second group of Peneroplids is characterized by the genus Sorites which is disk-shaped with a central depression. In cross-section this fossil appears as a dimpled quarter with vertical ridges (chambers) visible along an elongated rod (Figure 18h).

Pelecypods are bivalved molluscs such as clams, oysters, and scallops. While they are common in many of the geological strata that contain chert, they either are not well preserved or have been subject to fragmentation making their identification difficult. Where present and observable, they can provide important substantiating evidence for formational assignment. For example, Pecten molds are common in the Crystal River biozone of the Ocala Limestone and these often are preserved in the cherts that formed in this carbonate unit. Pelecypod tests also are common in Tampa limestone cherts and are occasionally observed in Suwannee Limestone cherts.

Corals. Corals are composed of aragonite, a form of calcium-carbonate. If the aragonite is dissolved prior to silicification, then the resulting void is filled with quartz resulting in "box-work geodes" (Strohm et al. 1981), similar to the famous Ballast Point coral geodes. These corals were rarely used for tool-making. More common was the use of replacement corals where the aragonite was removed contemporaneously with the process of silicification enabling preservation of the internal structure of the original host coral (Upchurch et al. 1982a:44). Although many coral species are preserved in Florida limestones, and these are often silicified, most were too small to serve as major sources of raw material for tool production. An exception is the large corals that belong to the genus Siderastrea (e.g., Weisbord 1973:23-28, Plate 4[Figure 3], Plate 5, Plate 6[Figures 1-3]). These distinctive corals are identified by a star-burst pattern of coral septae when the corals are fractured across the "grain" of the corallite. Other, less commonly used, corals exhibit honeycomb or paisley patterns.

Charophytes are fresh-water plants that secrete calcium carbonate. The reproductive oogonia of charophytes are occasionally preserved in cherts formed in the Tampa Limestone Member of the Hawthorn Group. These cherts appear to be restricted geographically to the upper Hillsborough River basin, particularly in the area around Cow House Creek, Flint Creek, and Harney Flats (Upchurch et al. 1982a:74, 140-141). Examples of this distinctive fossil are illustrated in Figure 18h.

Gastropods are univalve mollusks such as conchs, whelks, and drills. Well-preserved tests of small gastropods are occasionally found in Tampa Limestone cherts, and their quartz-lined tests are particularly common in cherts from the Lake Thonotosassa area in northeastern Hillsborough County where they sometimes are the only fossils that are observable. Occasionally, these are large enough to be seen with the unaided eye. Echinoids are included in the Phylum Echinodermata which includes marine animals with symmetrical, five-rayed bodies such as sea urchins and sand dollars. Their bodies consist of plates of calcium carbonate (calcite) and they are particularly common in the Suwannee Limestone where large, complete specimens are sometimes preserved. More common, however, are small fragments of the body plates. Since calcite fractures along right-angled cleavage planes, the Echinoid fragments are often rectangular or square in shape. The calcite is easily observable in freshly fractured chert, while in archaeological examples that have been exposed to chemical and physical weathering the calcite crystals have weathered out leaving rectangular-shaped voids.

Secondary inclusions. Other inclusions that are found in silicified rocks and are important in identification include quartz sand, phosphate, and pelletal material (peloids). Sand is a common component of Miocene age carbonates (Scott 1992:31; Upchurch et al. 1982a:20, 54) and so is found in replacement cherts that formed in the Tampa Limestone and the opaline cherts that formed in the overlying Hawthorn clays (Peace River Formation in central and south Florida). Sand also is found to a lesser extent in Suwannee Limestone cherts. Sand grains have a bright luster and are seen most easily under a strong, artificial light. Phosphate pellets are small, rounded inclusions that exhibit a waxy luster. They are variable in color with yellow, orange, tan, brown, and black being most common. They are found throughout the Peace River Formation of the upper Hawthorn Group. Peloids are small, rounded spheres of unidentified material. Jones and Squair (1989) suggest that peloids are actually fecal pellets from mites while Goodyear et al. (1983:58) are of the opinion that peloids in cherts around Tampa Bay are actually opal clasts. They are present in cherts that are found in the Hillsborough River and Tampa Bay areas, and are particularly diagnostic of a specific type, known as Bay Bottom chert, that is found in a restricted geographic range in and around the shores of Tampa Bay (Goodyear et al. 1983:58).

Color. As discussed above, color is not a very good identifying criterion; however, in combination with other features, color may sometimes be useful for identifying cherts from specific quarry clusters. For example, cherts derived from the Tampa Limestone Member of the Hawthorn Group may be black and opaque due to the inclusion of pyrite or organic material (Upchurch et al. 1982a:57). Suwannee Limestone cherts in the Upper Withlacoochee Quarry Cluster tend to be brown or reddish-brown in color due to the inclusion of iron while Suwannee cherts in the Brooksville Quarry Cluster tend to be lighter in color (Upchurch et al. 1982a:130, 134; S. B. Upchurch, personal communication, 1992).

Luster. Opal-rich cherts tend to have a waxy, lustrous appearance that is useful in their identification. Thermally altered and patinated artifacts also may have a lustrous surface, and care needs to be taken not to confuse these with opaline cherts. Thermal alteration often imparts a reddish or pinkish hue to the chert which assists in its identification (Purdy 1974:47; Rick 1978:18, 30).

Porosity. Secondary porosity, or voids caused by physical or chemical weathering after rock formation, sometimes is useful as a criterion in combination with other criteria to identify specific chert types. Suwannee Limestone is often characterized by many small pits and voids where calcite crystals have weathered out (Randazzo 1972:7), and replacement cherts that formed in this limestone also exhibit these pits. The opaline Hawthorn cherts in the Peace River Quarry Cluster also contain small pits where phosphate pellets and sand have weathered out.

Identification of Quarry Clusters

When the quarry-cluster method was originally developed, Upchurch et al. felt that cherts derived from the outcrops located in these quarry clusters could be distinguished from one another using the criteria just described. However, they were careful to note that the quarry clusters they proposed were subject to modification as more data accumulated (Upchurch et al. 1982a:93). They also acknowledged that problems existed in identifying cherts associated with some of their proposed quarry clusters, due primarily to small sample sizes in their study collection. For example, some quarry clusters (e.g., White Springs, Lower Suwannee, Turtlecrawl Point) had not been sampled adequately enough to provide unambiguous criteria for identifying cherts derived from them. Other proposed quarry clusters (e.g., Upper Suwannee, Inverness, Santa Fe) had not been sampled at all since no chert outcrops were known or observed by them. Their existence was based on a knowledge of regional geology, the expectation that chert should be present in these locations based on their model of chert formation, and the presence of archaeological sites with abundant chert artifacts. Some well-sampled quarry clusters (e.g., Ocala, Gainesville, Lake Panasoffkee) contain cherts that share many of the same diagnostic criteria making unambiguous assignments difficult. Finally, many more lithic outcrops have been sampled since Upchurch et al.'s study was conducted, increasing the representativeness of the comparative type collection. Some of these sample locations are in geographic areas that fall outside the boundaries of Upchurch et al.'s original quarry clusters. Others contain diagnostic criteria that differ from those that were believed to identify cherts within their proposed clusters.

For these reasons, I have modified Upchurch et al.'s original quarry cluster boundaries by reducing of the number of quarry clusters where: 1) cherts are derived from a single, geological formation, and 2) unambiguous criteria for distinguishing between the original quarry clusters are not present. Where new sample localities have been identified it has sometimes been possible to expand the boundaries of nearby quarry clusters if: 1) the new samples are from the same geological formation as the adjacent cluster, and 2) the identifying criteria are unambiguous. A map of the revised quarry clusters used in this study is provided in Figure 19. Table 8 provides information on the various chert types identified in this study and their defining criteria.

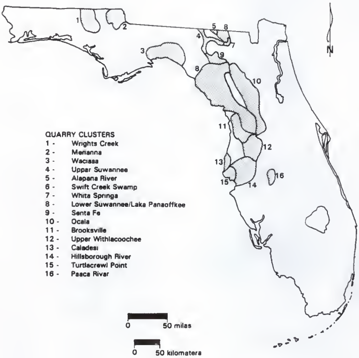


Figure 19. Map of quarry-cluster locations in Florida (modified from Upchurch et al. 1982a:Figure 1).

Table 8. Chert types and associated quarry clusters in central Florida.

Geological Formation	Chert Types and Diagnostic Criteria	Quarry Clusters
Peace River Formation, Hawthorn Group	Quartz replacement of opaline sediments. Dark gray, brown, or yellowish-brown in color with abundant phosphate pellets and quartz sand inclusions. Very fine-grained and brittle. Opal content gives this chert a natural luster. Corticates easily.	Peace River
	Porcelanite, light-colored, very lustrous, sometimes brecciated.	Hillsborough River
	Translucent, dark gray to black, quartz replacement of mudstones and opaline sediments. Homogeneous, fine-grained, with no observable inclusions.	Turtlecrawl Point
	Quartz replacement of opaline sediments. Dark gray to black, with light-colored peloids. Acquires a bluish-gray patina. Slight surface luster, occasional quartz sand inclusions.	Caladesi, particularly on Honeymoon Island.
Tampa Limestone Member, Hawthorn Group	Silicified coral, primarily Siderastrea.	Caladesi Hillsborough River
	Translucent chalcedonic chert. Gray, brown, or tan-colored with light-colored peloids in a wackestone fabric. Quartz sand and occasional fossil fragments are sometimes present.	Hillsborough River
	Fossiliferous packstone or grainstone. Peneroplids are abundant, quartz sand may or may not be present. Opaque, relatively coarse-textured material. Gray, brown, or tan in color.	Caladesi. Sorites are very common Hillsborough River. Very common around Tampa Bay and along the lower Hillsborough and Alafia Rivers.

Table 8 (Continued).

Geological Formation	Chert Types and Diagnostic Criteria	Quarry Clusters
	Bay Bottom chert. A peloidal packstone, occasionally brecciated. Opal clasts and large areas of chalcedenous void filling are common giving the chert a clotted or splotchy appearance. Peneroplids, particularly Sorites, are common fossil inclusions. Quartz sand is present in varying amounts ranging from rare to abundant. Color is variable and can be white, brown, light gray to dark gray.	Hillsborough River, Tampa Bay
	Cow House Creek chert. Silicified mudstone. Identified by the presence of charophyte oogonia.	Hillsborough River. Restricted to Cow House Creek, Flint Creek , and Harney Flats region of upper Hillsborough River.
	"Generic" quartz replacement of mudstones and wackestones. Color and fossil content are variable. Peneroplids, pelecypods, occasional small gastropods. Voids and burrows filled with chalcedony and quartz crystals.	Hillsborough River
	Dark gray to black chert; small fossil fragments, common sand.	Peace River. Appears limited to area between Ft. Meade and Wauchula.
Suwannee Limestone	Fossiliferous grainstone with many small foraminifera. Miliolids are diagnostic and Echinoid molds are common. Color varies from light gray, pale tan, to pink. Vuggy with numerous quartz sand inclusions.	Brooksville
	Fossiliferous grainstone. Color is variable, but tends to be darker than Brooksville QC cherts. Quartz sand may be present, but is not common. Fossils are larger than Brooksville cherts. Miliolids are diagnostic. Echinoid molds and Dictyoconous molds also are common.	Upper Withlacoochee

Geological Formation	Chert Types and Diagnostic Criteria	Quarry Clusters
	Silicified coral, primarily Siderastrea.	Brooksville Upper Withlacoochee
Crystal River Biozone, Ocala Limestone	Chalcedony replacement of fossiliferous grainstone or packstone. Orbitoid foraminifera and Pecten molds are diagnostic.	Ocala
	Chalcedony replacement of grainstone and packstones. Orbitoid foraminifera are small and widely spaced. Minor secondary porosity.	Lower Suwannee/Lake Panasoffkee
	Chalcedony replacement of grainstone and packstones at interface of Suwannee and Ocala Formations. Contains fossils diagnostic of both formations.	Upper Withlacoochee, Rock Ridge region.

NOTE: Tampa limestone cherts that can not be assigned to any of the more specific Tampa limestone chert types are referred to as "Generic." Most are probably derived from outcrops in the Hillsborough River Quarry Cluster.

The Ocala Limestone cherts are the most difficult to assign to a specific quarry cluster. Upchurch et al. (1982:116-126, 127) divided the Ocala Limestone exposures in central Florida into five quarry clusters: the Lower Suwannee, the Santa Fe, the Lake Panasoffkee, the Gainesville, and the Ocala. Cherts from the Ocala, Gainesville, and to some extent, the Lake Panasoffkee quarry clusters, all contain abundant, large, Orbitoid foraminifera, particularly species in the genus Lepidocyclina, and large Pecten molds in a grainstone fabric, while cherts from the Lower Suwannee and Santa Fe quarry clusters tend to have fewer and smaller Orbitoids (Upchurch et al. 1982:118, 120-121). Other criteria, such as the relative abundance of fossils, the presence of secondary porosity (vuginess), and the presence of pelletal material, are cited as possible keys to distinguishing between quarry clusters. However, as they note, "The absolute positions of boundaries between quarry clusters and, in fact, the very existence of these clusters as distinguishable entities is subject to revision...[T]he five quarry clusters. are difficult to separate megascopically and may devolve into a smaller number of clusters as we learn more. " (Upchurch et al. 1982a:120, 121).

My own examination of cherts from all five of these quarry clusters indicates that it is very difficult to distinguish between cherts derived from the Ocala, Gainesville, and Lake Panasoffkee quarry clusters. An exception appears to be cherts located to the north of Lake Panasoffkee. Rich Estabrook (personal communication, 1995) indicates that outcrops there have fewer Orbitoids than Ocala Limestone cherts located to the north and east. Examination of samples obtained from outcrops in this area confirm his observations and, further, indicate that the Orbitoids are smaller. These cherts resemble those from the Santa Fe and Lower Suwannee quarry clusters more closely than they do the more northerly Ocala Limestone cherts. Therefore, I have separated the Ocala Limestone cherts in central Florida into two groups: an eastern cluster consisting of the Ocala, Gainesville, and lower Lake Panasoffkee quarry clusters of Upchurch et al., and a western cluster that includes the Lower Suwannee, Santa Fe, and northern Lake Panasoffkee quarry clusters. I refer to the former as the Ocala Quarry Cluster and to the latter as the Lower Suwannee/Lake Panasoffkee Quarry Cluster. Upchurch et al.'s northern Lake Panasoffkee cluster and the Lower Suwannee cluster are separated by exposures of lower Eocene strata, formerly referred to as the Inglis and Avon Park Formations (Upchurch et al. 1982a:Figure 2). No chert exposures are known for this area, but future research may modify this.

I have retained Upchurch et al.'s division of Suwannee Limestone cherts in peninsular Florida into two quarry clusters -- the Brooksville and Upper Withlacoochee -- with the distinction between these based primarily on an increase in quartz sand content in the Brooksville cherts (Upchurch et al. 1982a:129). Although quartz sand is present in some of the Upper Withlacoochee cherts, Brooksville cherts do tend to have comparatively greater amounts of sand. Color is another suggested criterion for distinguishing between cherts in these two quarry clusters with the Brooksville cherts generally tending towards lighter colors.

The Withlacoochee Quarry Cluster also contains outlying exposures of Ocala Limestone which are located in the Rock Ridge region of northwestern Polk County (Stewart 1966:36; Upchurch et al. 1982a:Figure 2). Stewart (1966:36-37) reports that chert lying at the interface between the Ocala and overlying Suwannee limestones contains fossils diagnostic of both formations

In the Hillsborough, Caladesi, and Turtlecrawl Point quarry clusters, where chert outcrops are numerous, well known, and well sampled, it has been possible to distinguish between chert types within these quarry clusters. Goodyear et al. (1983:56-61) refer to these chert varieties as Types 1-5 and have mapped their locations. Type 1 chert is silicified coral. Type 2 chert is a dark-colored quartz replacement of opaline sediments that is very common in outcrops on Honeymoon Island in Pinellas County, which is within the Caladesi Quarry Cluster A similar appearing chert is found in the Turtlecrawl Point Quarry Cluster, but the Honeymoon Island chert can be distinguished from this latter type by the presence of light-colored peloids and occasional quartz sand inclusions. Type 3 chert is a translucent, chalcedonous chert, pale brown, tan, or gray in color, and contains light-colored peloids. It is found along the lower Hillsborough River and in several locations around Tampa Bay. Type 4 chert is a fossiliferous packstone or grainstone that occurs in outcrops within both the Caladesi and Hillsborough River quarry clusters. Type 5 chert is a distinctive peloidal packstone, commonly referred to as "Bay Bottom" chert, that outcrops around Tampa Bay.

Classification of Archaeological Specimens

Archaeological specimens were compared to chert samples from all of the identified quarry clusters in Florida to ensure accurate identification. These samples include the large type collection developed by Sam Upchurch which is presently housed at the Florida Museum of Natural History (accession numbers 93-1 and 93-15), as well as chert samples from known source locations available at the laboratory of Janus Research and in my personal possession. These type collections comprise a set of data and samples from over 200 chert locations in Florida. Although these type collections are far from complete, in that not all quarries or outcrops in the state have been sampled, they are sufficiently large enough to be representative of the diagnostic features that characterize the cherts contained within most of the major quarry clusters.

All specimens were examined under a Bausch and Lomb Stereo-Zoom Seven binocular microscope with a maximum magnification of 70x. Individual artifacts were occasionally moistened to better reveal specific characteristics such as fossil content and rock fabric. Specific artifacts that proved particularly difficult to identify were submitted to Upchurch for verification of chert type/quarry cluster origin.

Assignment of individual specimens proceeded in a hierarchical fashion. The approach focused first on identifying the geological formation from which the chert was derived since this assignment is the least ambiguous. I then attempted to assign individual artifacts to a specific quarry cluster. Finally, an attempt was made to assign a specimen to specific chert types within those quarry clusters where such types have been identified. Those specimens that could not be confidently identified were classified as "undetermined."

It should be noted that many quarry clusters in north Florida and the panhandle share some of the diagnostic criteria with cherts derived from similar geological formations in central Florida. For example, Suwannee Limestone cherts in the Wacissa and Upper Suwannee quarry clusters are typically vuggy, fossiliferous grainstones with diagnostic Miliolid, Dictyoconus, and Echinoid fossil inclusions. To deal with this problem, I have assumed that, all else being equal, humans will expend the minimum amount of energy necessary to obtain a needed amount of raw material. This assumption implies that only the most readily available lithic resources will be utilized. Thus, if lithic artifacts can be assigned to specific geological formations, those source locations (quarry clusters) that contain cherts from these formations and which are closest to the site or study area are assumed to have been the origin of the lithic materials. This approach has been used successfully by Blakeman (1977) in his study of prehistoric chert procurement in Alabama. A similar "source area" or regional approach was utilized by Hurtado de Mendoza and Jeter (1978) and Michels (1982) in their studies of obsidian procurement in Guatemala. In Florida, Austin (1996b), Estabrook (1992), Estabrook and Williams (1992), and Goodyear et al (1983) have utilized this approach to study chert procurement and use in a wide range of archaeological contexts.

Statistical Analysis of Data

Statistical analysis was limited somewhat by the non-random nature of the database and by the small sizes of the samples. Consequently, I have attempted to keep the statistical analysis of data relatively simple and straight-forward. Most of the techniques that I have used make minimal assumptions regarding sample size and underlying probability distributions. When more sophisticated techniques were used, the primary goal was to determine if patterning in the data exists rather than to establish the statistical significance of these patterns.

With one exception, all statistical calculations were performed using SPSS for Windows™ and GBStat™. Non-parametric tests of significance such as chi-square and the Kolomogorov-Smirnov test were used to test for statistical independence of nominal data sets. Both tests are fairly robust and do not require that the sample data be normally distributed. The Student's *t* test was used to test for statistical independence of sample means.

Chi-square and the Student's *t* should be familiar to most archaeologists, as they are perhaps two of the most commonly used of all statistical tests. The Kolomogorov-Smirnov test is used to test the null hypothesis that two samples have been selected from identical populations. If true, then the cumulative frequency distributions of the samples should be similar (Blalock 1972:262). If the maximum difference between the two cumulative distributions is larger than would be expected by chance, then the null hypothesis is rejected and the two samples are said to have come from different populations. Discussions of the logic and application of these tests can be found in any standard statistical text (e.g., Blalock 1972; Davis 1973; Shennan 1990).

Regression analysis also is commonly used in the analysis of archaeological data. In addition to the previously cited texts, Hodder and Orton (1976) and Doran and Hodson (1975) provide thorough explanations and relevant examples of the use of regression analysis with archaeological data. Although traditionally applied for the purpose of predicting the effect of an independent variable (*X*) on a dependent variable (*Y*), I have used regression analysis in this study to characterize different distance-decay relationships. Distance from raw-material source locations is the independent variable while the dependent variable is either a measure of abundance, usually expressed as a proportion or percentage value, or a measure of size. I have also used regression analysis to characterize the shapes of flake-size distributions, as is discussed in more detail below.

The goal of regression analysis is to find the unique curve that best fits the distribution of data points such that the sum of the squares of the deviations from this line is at a minimum. Often this curve will be a straight line, but sometimes the relationship between X and Y is non-linear and a hyperbolic, exponential, or power curve may offer the best fit. In fact, according to Hodder and Orton (1976:101), most distance-decay relationships are non-linear in form. The strength of the regression relationship is expressed by the correlation coefficient, r, which is the ratio of the covariation of X and Y divided by the square root of the product of the standard deviations of X and Y (Blalock 1972:378). The measure ranges from -1.0 to 1.0; the stronger the relationship, the larger the value of r. The amount of variation explained by the relationship between X and Y is expressed by r^2.

An important feature of the correlation coefficient, especially with small samples, is that it can be affected by a few extreme values of either the X or Y variables. Depending on the problem, Blalock (1972:381-383) and Hodder and Orton (1975:103-104) suggest eliminating extreme values or, alternatively, displaying the results of the regression analysis, along with correlation coefficients, both with and without the extreme values. While there are no strict rules for making this decision, visual examination of the scatterplot of the original data points or a plot of the residual values (i.e., the actual value of *Y* minus the predicted regression value) can be used to aid the analyst in determining whether extreme values are unduly influencing analysis results (Blalock 1972:381; Shennan 1990:145-146). The patterns exhibited by the positive and negative residuals themselves often provide illuminating information that can assist in interpretation (Hodder and Orton 1976:115-126).

Three other statistical applications require a more extended discussion: discriminant-function analysis, statistical comparison of regression slopes using Analysis of Variance (ANOVA), and analysis of assemblage diversity.

Multivariate Classification of Debitage Assemblages

The experimentally produced debitage assemblages that are discussed in Chapter 8 were analyzed and then compared to archaeological waste-flake assemblages using a multivariate technique known as discriminant function. Discriminant-function analysis transforms an original set of raw variable scores for two or more samples or assemblages into individual discriminant scores that represent each sample's position along a line described by the linear discriminant function. The technique requires that the samples first be separated into mutually exclusive categories using criteria that are independent of the variables that will be used in the analysis. In this study, the experimental flake assemblages were separated into groups based on a priori knowledge of their origin; in other words, patterned-tool or core reduction. Then, using the original variable scores, the analysis attempts to find a transform that maximizes the separation between group clusters when plotted in multidimensional space, while at the same time minimizing cluster spread (Davis 1973:442-452). The variables used to distinguish between experimental assemblages were the Sullivan-Rozen flake categories described above. The data consisted of the counts or frequencies of flakes from each experimental assemblage that were assigned to the four flake categories. If the discriminant analysis is successful in distinguishing between the previously identified groups, a formulae is produced that enables unknown samples or assemblages to be classified into one of the identified groups using the same set of variables.

Statistical Comparison of Flake-Size Distributions

As mentioned above, regression analysis was used to characterize the flake-size distributions of experimental and archaeological waste-flake assemblages. The raw data consisted of the percentages of flakes in each assemblage contained in each of the .5 cm size classes described above. Since the resulting flake-size distributions are typically exponential in form (see Chapter 8), the percentage values were transformed into their natural logarithms to create a straight-line relationship (Shennan 1990:146-147), and a regression line was fitted to these transformed data. For this analysis the midpoints of the various size classes were used in the regression calculations. For the smallest (<1) and largest (>6) size classes midpoint values of .75 and 6.25 were used.

The basic linear regression equation is:

$$Y = a + bX$$

where a = the intercept of the regression line with the Y axis and b = its slope. Fitting regression lines to the flake-size data thus enables a statistical calculation of slope (b) which can be used to compare and distinguish between different flake-size distributions. Comparison of two or more flake-size distributions can be done visually; however, it is possible to test statistically the null hypothesis that two regression slopes are homogeneous, i.e., that two samples came from populations with equal slopes. This can be done using analysis of variance (ANOVA) following the procedures of Sokal and Rohlf (1981:499-509) to calculate the sums of squares among and between the regressions of the individual samples.

The equation for calculating the sum of squares among bs with k - 1 degrees of freedom is given by Sokal and Rohlf (1981:501) as.

$$SS_{\text{among b's}} = \sum \left(\sum^{k} \hat{y}^2\right) - \sum \hat{y}^2_{\text{pooled}}$$

where $\hat{y}^2$ = the square of the predicted value of $Y - \bar{Y}$ for each sample k, and

$$\hat{y}^2_{\text{pooled}} = \left(\sum \sum^{k} xy\right)^2 \div \sum \sum^{k} x^2$$

where $xy = \mathrm{X} - \bar{\mathrm{X}} * \mathrm{Y} - \bar{\mathrm{Y}}$, and x^2 = the square of $\mathrm{X} - \bar{\mathrm{X}}$.

Analysis of Assemblage Diversity

Measurement of diversity. In Chapters 9 and 10 I utilize the concept of diversity in the contexts of risk-abatement and cost-minimization strategies. When archaeologists discuss diversity they usually are referring to a dual concept that incorporates measures of both richness and evenness (Peet 1974). Richness refers to the number of taxa, species, or types that are present in the population (or archaeological assemblage) of interest, and so essentially is a measure of variety. Evenness refers to the proportional distribution of individuals between the taxa, species, or types represented within a population or assemblage. A single measurement that attempts to take into account both richness and evenness is referred to as heterogeneity (Peet 1974:287-288). A number of different formulae have been developed to quantify heterogeneity, but despite the appeal of representing a bivariate relationship with a single quantitative measure, Bobrowsky and Ball (1989:7) caution against the use of heterogeneity measures since they tend to mask the important individual properties of richness and evenness. Therefore, I have chosen to use relatively simple, intuitively understandable, and analytically independent measures of both richness and evenness. Interpretation of assemblage diversity is achieved by plotting the resulting values on a bivariate graph. Using this approach, it is possible to preserve the individual properties of richness and evenness while simultaneously observing how both contribute to overall assemblage diversity.

I have chosen to calculate richness (*R*) as a simple proportion:

$$R = (n_i \div N) * 10$$

where n_i = the number of types (e.g., raw-material types, artifact classes) present in an assemblage, and N = the maximum number of types identified in the study collection. A simple estimate of evenness (*E*) is the standard deviation of the proportional abundance of types within an assemblage (Fager 1972). The standard deviation is a measure of the dispersion of values around the mean of a population; the larger the standard deviation, the greater the spread of values around the mean. A small standard deviation indicates that population values closely approximate the mean. In the case of raw-material types and artifact classes, the mean value calculated for each assemblage provides an estimate of an even distribution of individual specimens between all types represented in the study collection. The degree to which the actual distribution of individual specimens differs from this theoretically even distribution is expressed by the standard deviation.

Because the raw data consist of counts of specimens assigned to each type (i.e., nominal data), the absolute values of the mean and standard deviation of each assemblage are directly affected by the sizes of the samples making it difficult to make direct comparisons between assemblages of different sizes. A standardized measure of dispersion, known as the Coefficient of Variation (CV), can be used to represent evenness in place of the standard deviation. It is calculated by dividing the standard deviation by the assemblage mean (Shennan 1990:44-45); the lower the CV, the closer the proportional abundance of types in an assemblage approximates the mean and the more even the distribution. The CV is subtracted from a constant (10) to create a measure of evenness that increases as the distribution of types in an assemblage becomes more even. Thus, the formula for evenness is:

$$E = 10 - (s_i \div a_i)$$

where s_i = the standard deviation of the absolute abundance of types in an assemblage and a_i = the mean.

Monte Carlo simulation of assemblage richness. Several researchers have indicated that sample size can affect class richness (e.g., Jones et al. 1983; Kintigh 1984, 1989), with larger samples having a greater chance of containing more classes. One way to approach this problem is to develop an expectation for richness based on sample size. Kintigh (1984, 1989) has developed a method for doing this by generating simulated assemblages of various sample sizes. The aggregate information obtained from these multiple simulations yields a statistical estimate (i.e., a mean or average value) of richness for specific sample sizes. These are then plotted on a log-linear graph and the actual richness values for the archaeological samples are compared to the expected richness values. The method is operationalized using the DIVERS program (Kintigh 1994). Two hundred simulated samples were randomly generated for sample sizes ranging from 1 to 2000 with the maximum sample size dependent on the largest sample size among the archaeological assemblages used in the analysis. The results are plotted on a log-linear graph which includes the resulting mean (expected) values, the 90 percent confidence interval around the means of the simulated samples, and the richness values for the actual archaeological assemblages. Assemblages that are positioned below the 90 percent confidence interval are interpreted as having lower-than-expected class richness while those positioned above it are interpreted as having higher-than-expected richness.

In addition to the general methods discussed in this chapter, other typologies were used, measurements obtained, and data compared and analyzed to test specific hypotheses. These are described as necessary in the appropriate chapter sections.

CHAPTER 8
DIFFERENTIATING BETWEEN TOOL PRODUCTION AND CORE REDUCTION IN LITHIC WASTE-FLAKE ASSEMBLAGES: ANALYSIS OF EXPERIMENTAL DATA

This chapter presents the results of experiments conducted for the purpose of refining two techniques used in this study to examine variability in debitage assemblages: the Sullivan-Rozen flake typology and the analysis of flake-size distributions (see Chapter 7 for a full discussion of these techniques). As Amick et al. (1989:1) have observed, the results of experimental research cannot be used in a direct way to interpret the archaeological record. Instead, experimental data provide the basis for models that can be compared to the archaeological record. Models, however, are only approximations of reality. As a result, we should expect ambiguities to appear between the models we construct and the reality of the archaeological record. These ambiguities provide the basis for further research, experiment, and testing.

Much experimental work has been conducted by others to increase the reliability of the inferences that are made using both the Sullivan-Rozen typology and flake-size distribution analysis on archaeological assemblages. One of the major conclusions reached after reviewing these studies is that variability in flake assemblages can result from a number of factors that may be only indirectly related to the principal domain of interest, in this case, the specific reduction strategies employed. These factors may include variability in the properties of the raw materials used in lithic-reduction experiments, the skill level(s) of the flintknapper(s), percussor type, the intended final form of the artifact, collection and recovery methods, and observer error in classification.

One reason for using the Sullivan-Rozen typology and a flake-size distribution analysis is that both are relatively simple and easy to use. Subjective decision-making is kept to a minimum and the analyst is able to characterize entire debitage assemblages quickly and with a high degree of replicability. Other factors, however, such as raw-material variability, are unique to local conditions. Thus, while it would have been possible to use existing experimental data to construct usable models that could be tested against the archaeological collections used in this study, it was felt that more reliable inferences could be made by using local materials in a manner likely to be more consistent with local tool-making traditions.

The experimental waste-flake assemblages used in this study were derived from a series of 15 experimental replications. The replications produced hafted bifaces, unifaces, and flake tools, as well as debitage and cores associated with each of these reduction strategies. Details of materials and methods used in these replications are presented in Chapter 7. Table 9 provides basic data on raw materials, initial core/blank size or weight, the total number of flake removals retained in the 1.6 mm screen, and the number of flake removals retained in the 6.4 mm screen for all 15 experimental assemblages.

Sullivan-Rozen Flake Typology

Background, Debate, and Previous Experimental Research

In 1985, Sullivan and Rozen introduced a new method for classifying lithic debitage from archaeological sites. Their reasons for doing so were: 1) to avoid a priori assumptions regarding the technological origins of debitage, and 2) to create an objective and replicable system for classifying flakes (Sullivan and Rozen 1985:755, 758). Their classification system was based on flake morphology, and they used three dimensions of variability to place individual specimens in one of four mutually exclusive categories. These three dimensions included: 1) the presence of a single, discernable, interior surface, 2) the presence of a point of applied force (i.e., striking platform), and 3) the presence of intact

Table 9. Summary of experimental replications

Replication	Raw Material	Original Core Size	# Flakes Removed[a]	# Flakes >6.4 mm[b]
Hafted Biface #1	Silicified Coral	98.7 gm	1143	115
Hafted Biface #2	Peace River QC Chert	342.8 gm	2162	235
Hafted Biface #3	Silicified Coral	44.7 gm	490	36
Bifaces (3) #4	Silicified Coral	Not measured	945	239
Uniface #1	Silicified Coral	372.8 gm	1154	160
Uniface #2	Peace River QC Chert	902.8 gm	c	267
Uniface #3	Peace River QC Chert	66.0 gm	490	42
Large Core Reduction #1	Peace River QC Chert	Large, unblocked chert nodule	436[d]	60[d]
Large Core Reduction #2	Silicified Coral	220x210x150 mm	610[e]	196[a]
Large Core Reduction #3	Silicified Coral	190x180x110 mm	80[f]	13[f]
Small Core Reduction #1	Ocala QC Chert	Not measured	161	20
Small Core Reduction #2	Ocala QC Chert	Not measured	364	59
Small Core Reduction #3	Brooksville QC Chert	115x81x76 mm	404	58
Small Core Reduction #4	Withlacoochee QC Chert	82x81x57 mm	291	47
Small Core Reduction #5	Hillsborough River QC Chert	141x98x54 mm	600	101

[a] Includes all flakes retained in 1.6 mm mesh hardware cloth.

[b] Includes all flakes retained in 6.4 mm mesh hardware cloth, except as noted.

[c] Flakes that passed through the 6.4 mm mesh screen were not retained.

[d] Does not include four flake blanks removed for further reduction.

[e] Does not include two flake blanks removed for further reduction.

[f] Does not include one flake blank removed for further reduction.

lateral and distal margins (Sullivan and Rozen 1985:758-759). The four mutually exclusive flake categories included complete flakes, broken flakes, flake fragments, and debris. These categories were subsequently renamed -- complete flakes, proximal flakes, medial-distal flakes, and nonorientable fragments -- and a fifth category, split flakes, was added to the typology (Rozen 1984; Sullivan 1987).

As argued by Sullivan and Rozen, the use of these flake categories does not imply or assume any technological processes. The categories are purely descriptive and encompass the full range of morphological variability found in lithic waste flakes. Thus, unlike typologies that attempt to identify flake types that resulted from specific lithic-reduction activities or stages of reduction (e.g., primary flakes, secondary flakes, biface-thinning flakes, bipolar flakes, notching flakes, blades, etc.), the Sullivan-Rozen categories are "interpretation free" (Sullivan and Rozen 1985:758). Because no technological assumptions are made prior to classification, the flake categories provide an independent means of interpreting archaeological assemblages. Furthermore, the ability to identify flake types that are diagnostic of specific activities or stages is sometimes difficult, often subjective, and at best accounts for only a small fraction of the lithic waste flakes in any assemblage.

Once they had defined the flake categories, Sullivan and Rozen went on to demonstrate how they could be used to interpret archaeological assemblages. Their analysis of flake assemblages from east-central Arizona indicated differences in the proportional representation of different flake categories between sites. Sullivan and Rozen interpreted these assemblage differences to be the result of different reduction strategies. According to them, waste-flake assemblages that contained a high percentage of complete flakes and nonorientable fragments represented intensive core-reduction activities. Assemblages that contained a high percentage of proximal and medial-distal fragments, and a low percentage of nonorientable fragments, represented patterned-tool manufacture. Mixed assemblages containing flake debris resulting from both of these technologies were represented by relatively equal proportions of complete flakes, proximal fragments, and medial-distal fragments (Sullivan and Rozen

1985:762-763). They based these inferences on a presumed increase in the tendency for small, thin flakes typically produced during tool manufacture to fracture during removal. The basis for this assumption is not entirely clear, and Sullivan and Rozen cited no experimental studies to support it (however, see Whitaker 1994:187). They then went on to test these initial interpretations using a different set of attributes (Sullivan and Rozen 1985:764-766).

Although initially well received and widely used, the method soon began to be criticized in the literature. Amick and Mauldin (1989) published the first widely read critique in American Antiquity. The basis of their criticism rested on what they termed "the methodology of inference" (Amick and Mauldin 1989:167). They criticized Sullivan and Rozen for making the very error they were trying to avoid by assigning meaning to the archaeological record without a demonstrated linkage via experimental research. That is, without an independent, empirically based, experimental program which would demonstrate the validity of using their flake categories to make technological inferences, their conclusions were, by necessity, based on the very archaeological record they were trying to explain.

In the same issue, Ensor and Roemer (1989) attacked Sullivan and Rozen along similar lines, questioning whether their flake categories (or any classification system, for that matter) could ever be purely interpretation free. They also questioned Sullivan and Rozen's rejection of the widely used stage typologies which attempt to identify steps or stages in the continuum of lithic reduction (cf. Callahan 1979; Collins 1975; Muto 1971).

In their responses to these critiques, Rozen and Sullivan (1989a, 1989b) noted that use of the phrase "interpretation free" was meant to be applied to the flake categories, and that criticism of the use of this phrase was erroneously directed at their interpretation of archaeological assemblages. Second, they argued that the interpretations they offered regarding assemblage composition were grounded in previous experimental work (although the references they cite in their responses were used in the original paper to support their use of secondary attributes to test the inferences derived from their independent flake classification), and further, they doubted whether additional experiments designed to identify different reduction strategies would be successful because: 1) closely related tool forms (e.g., projectile points and bifacial knives) may produce similar flake assemblages, 2) a single tool form may be produced by a number of different reduction sequences and so produce different flake assemblages (e.g., bifaces produced by nodule reduction versus flake-blank reduction), and 3) some archaeological assemblages may be the result of nonproduction-related activities such as secondary refuse disposal (Rozen and Sullivan 1989a:172). They reiterated that their primary goal in creating the typology was to illustrate an approach to lithic analysis that did not require technological inferences to be made at the level of the artifact (Rozen and Sullivan 1989b:182).

Despite these attempts to respond to criticism, it was clear to many archaeologists who used the typology that significant problems existed. Unlike Sullivan and Rozen, these archaeologists believed that additional experimental research held the potential for rectifying some of the problems that emerged from the debate. As a result, several experimental programs were initiated to refine the typology and its implementation in archaeological contexts. The most ambitious of these was the extended series of experiments conducted by William Prentiss, who attempted to examine a variety of technological and nontechnological factors that might affect the proportions of flakes in each of Sullivan and Rozen's categories within a given assemblage. His results indicated that some of the assumptions of Sullivan and Rozen were, in fact, flawed. For example, he found that both tool production and high-impact core reduction can produce medial-distal fragments in relatively high numbers, contrary to Sullivan and Rozen's initial interpretations (Prentiss and Romanski 1988, 1989). In addition, nontechnological factors such as trampling can result in inflated numbers of broken flakes (both proximal and medial-distal fragments). Thus, the presence of nonorientable fragments becomes a key indicator of core reduction (cf. Magne and Pokotylo 1981:37), particularly when found in association with low numbers of proximal flakes and a high proportion of complete flakes (Prentiss and Kuijt 1988:9).

The fracture properties of different types of raw materials also may affect the distribution of flakes between the various categories. Prentiss and Romanski (1989:93) suggested that tougher cherts may be less likely to fracture and so would tend to produce more complete flakes than more brittle, fine-grained materials. The presence of incipient fracture planes and inclusions would also tend to contribute to a greater number of broken flakes. If their reasoning is correct, then one also would expect greater amounts of broken flakes in assemblages dominated by thermally altered material which increases the fracture properties of tougher cherts. However, experimental data presented by Odell (1989:Table 1) indicates that more complete flakes are produced during the bifacial reduction of thermally altered chert than unaltered chert. His experiments were not designed to test this proposition directly, and non-thermally altered material was used during early-stage biface reduction while thermally altered chert was used during late-stage thinning and shaping. Thus, factors such as the use of different percussors (i.e., hard hammer versus soft hammer and pressure flakers) were not controlled for and could explain this contradictory result.

Prentiss also attempted to test the assumption that different reduction strategies will result in significantly different assemblages of flakes. He manufactured and compared biface-, uniface-, and core-reduction assemblages using the Sullivan-Rozen typology. His results indicated that biface and uniface flake assemblages are difficult to distinguish using this typology, but both can be distinguished from spheroid- and block-core-reduction assemblages with the latter characterized by high proportions of nonorientable fragments and moderate proportions of complete flakes and medial-distal fragments (Prentiss and Romanski 1989:91-93). These results were confirmed by Ingbar et al. (1989) who compared biface flake assemblages derived from the reduction of flake blanks to the biface-, uniface-, and core-reduction flake assemblages of Prentiss and Romanski (1989). They found no significant differences between biface and uniface assemblages; however, when biface and uniface debitage were combined into a single, patterned-tool assemblage, they found this combined assemblage to be statistically different from the block-core flake assemblages (Ingbar et al. 1989:121).

Recently these experiments have been extended to include bipolar reduction (Kuijt et al. 1995). The results indicate that flake assemblages resulting from this specialized type of core reduction can be distinguished by the exceptionally high proportions of medial-distal and nonorientable fragments, and the correspondingly low proportions of complete flakes and proximal fragments (Kuijt et al. 1995:122-124).

Using a slightly different set of flake categories, Mauldin and Amick (1989) showed that the manufacture of bifacial implements from chert nodules can produce a large number of complete flakes, a relatively low number of proximal flakes, and large amounts of "shatter" which in their study included both medial-distal and nonorientable fragments. Furthermore, the proportional representation of the various flake categories varied substantially between the three replicated assemblages, causing Mauldin and Amick (1989:83-84) to lament that archaeological interpretation of these assemblages based on Sullivan and Rozen's original assertions might lead one to conclude that at least two, and possibly three, different kinds of reduction assemblages were represented. They go on to suggest that differences in percussor type and core size and shape may affect flake breakage rates (Mauldin and Amick 1989:84).

Odell's (1989b) experiments in biface and core reduction indicated that core reduction produces slightly greater percentages of complete flakes versus broken flakes (which included both proximal flakes and medial-distal fragments). While the differences were not great, they did tend to support Sullivan and Rozen's original contention.

Tomka (1989) compared two biface assemblages -- one made from a chert nodule, the other from a flake blank -- with a flake assemblage derived from the reduction of a multidirectional core. He found that when the proportions of flakes in each flake category were compared (his complete, proximal, chip, and chunk categories are equivalent to Sullivan and Rozen's complete, proximal, medial-distal, and nonorientable categories), the shapes of the resulting distribution curves were similar; however, the proportional differences in each category were different enough to be able to distinguish the three reduction sequences from one other. Similar to the results of other experimenters, the core assemblage produced more chunks (i.e., non-orientable fragments) and fewer proximal fragments than either of the biface assemblages. However, the biface produced from a flake blank produced the greatest proportion of complete flakes while the biface produced from the chert nodule produced the lowest.

Finally, Bradbury and Carr (1995) compared a composite flake assemblage resulting from the production of seven core-reduction experiments using chert nodules to a composite assemblage of soft-hammer flakes resulting from the late-stage reduction of bifaces. Their results indicate that biface reduction does indeed produce a greater proportion of proximal flakes and many fewer nonorientable fragments than core reduction; however, the proportions of medial-distal fragments were nearly identical and complete flakes were only slightly more abundant in the core-reduction assemblage (Bradbury and Carr 1995:Table 13). Based on their review of previous experiments in combination with their own experimental data, Bradbury and Carr (1995:112) concluded that while observable differences exist between major reduction strategies, not all experiments have produced the same results. The discrepancies that exist are not consistent between experiments, and so they express some doubt regarding the viability of the Sullivan-Rozen typology as an interpretive tool.

Comparison of previous experimental data The raw data for the various experiments discussed above are presented in Table 10. Figure 20a compares the cumulative percentages of the four flake categories for both Prentiss and Romanski's (1989) and Kuijt et al.'s (1995) experimental assemblages. Figure 20b provides a similar comparison of Tomka's (1989) core and biface assemblages. As this figure shows, the block- and spheroid-core assemblages of Prentiss and Romanski are easily separated from their biface and uniface assemblages by the low proportions of complete flakes and the very high proportions of nonorientable fragments in the core-reduction assemblages. Kuijt et al.'s bipolar-core

Table 10. Comparison of flake-breakage patterns between different reduction strategies. Except as noted, all experimental assemblages were sifted through 6.4 mm hardware cloth prior to analysis.

Experiments	Complete		Proximal		Medial-Distal		Non-Orientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Prentiss & Romanski 1989[a]									
Biface	43	35.54	28	23.14	45	37.19	5	4.13	121
Uniface	12	30.77	9	23.08	14	35.90	4	10.26	39
Block Core	16	26.67	19	16.67	14	23.33	20	33.33	60
Spheroid Core	7	17.50	8	20.00	11	27.50	14	35.00	40
Tomka 1989[b]									
Multidirectional Core	101	49.27	14	6.83	78	38.05	12	5.85	205
Biface	63	33.69	36	19.25	85	45.45	3	1.60	187
Dart Point	90	57.69	21	13.46	43	27.56	2	1.28	156
Bradbury and Carr 1995									
Bifaces (4)[c]	213	27.90	175	22.90	376	49.20	0	0.00	764
Cores (7)	177	33.70	41	7.80	274	52.20	33	6.30	525
Kuijt et al. 1995[a]									
Bipolar Cores (9)	49	12.07	1	0.25	173	42.61	183	45.07	406
Mauldin & Amick 1989[d]									
Bifaces (3)	499	40.21	141	11.36	601	48.43	d	d	1241

Table 10 (Continued).

Experiments	Complete		Proximal		Medial-Distal		Non-Orientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct	
Odell 1989b[e]									
Bifaces (3)	417	20.54	f	f	1613	79.46	f	f	2030
Cores (6)	404	28.98	f	f	990	71.02	f	f	1394

[a] These researchers used a fifth category, "split flakes," which is not included in this table since other experimenters did not regularly employ this category in their analyses.

[b] Tomka's original categories of "chip" and "chunk" are analogous to Sullivan and Rozen's "medial-distal" and "nonorientable" fragments.

[c] Bradbury and Carr's biface assemblage includes only soft-hammer flakes.

[d] Mauldin and Amick's original flake typology did not distinguish between flakes without striking platforms (i.e., medial-distal fragments) and angular, nonorientable fragments. These were both included in their "shatter" category and are here placed within the "medial-distal" category.

[e] This table includes only those flakes from Odell's original data set that measure greater than 10 mm in order to be comparable to the other assemblages which were sifted through 6.4 mm hardware cloth.

[f] Odell distinguished only between "complete" and "broken" flakes in his original data table. His "broken" flakes have been placed in the "medial-distal" category in this table.

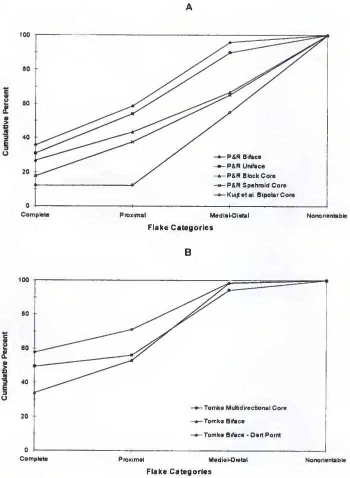


Figure 20. Comparison of cumulative percentages of Sullivan-Rozen flake categories among experimental assemblages from several different studies: a)Prentiss and Romanski (1989) and Kuijt et al. (1995); b) Tomka (1989).

assemblage is identifiable by the very low proportion of proximal flakes and the high proportions of medial-distal and nonorientable fragments. Similarly, Tomka's dart point (biface) produced from a flake blank produced a debitage assemblage with a large proportion of complete flakes and a comparatively small proportion of medial-distal fragments, and is easily separated from his biface flake assemblage produced from a chert nodule and from his multidirectional-core assemblage. His multidirectional core flake assemblage is characterized by a low proportion of proximal fragments and a relatively large proportion of nonorientable fragments.

When Prentiss and Romanski's biface and uniface assemblages are compared to Tomka's biface assemblages (Figure 21a) there is little difference between the two experimental flake assemblages resulting from the reduction of chert nodules. Prentiss and Romanski's uniface assemblage contains more nonorientable fragments than the biface assemblages. All have moderately low amounts of complete flakes and large amounts of medial-distal flakes. However, Tomka's dart point made from a flake blank clearly produced a much different flake assemblage, with complete flakes comprising nearly 60 percent of the assemblage.

Figure 21b compares the various core assemblages of Prentiss and Romanski (1989), Tomka (1989), and Kuijt et al. (1995). There are clear distinctions between all three. The bipolar-core assemblage, with its large numbers of medial-distal and nonorientable fragments, is a reflection of the technique itself which consists of resting a small nodule on a stone anvil and striking the core with a hard hammer at a nearly perpendicular angle to the striking platform. Blocky "shatter" (i.e., nonorientable fragments) tends to be characteristic of this technology (Ahler 1989a:210; Boksenbaum 1980; Kobayashi 1975).

It is unclear why Prentiss and Romanski's core assemblages diverge so much from that of Tomka, although original core size, differences in percussor types, or differences in raw-material properties may be factors. Tomka's core was small in size (37 x 34 x 28 mm) and reduction was geared

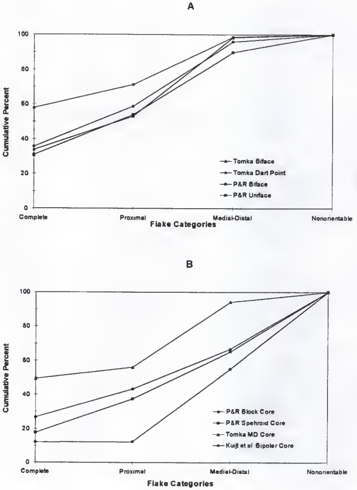


Figure 21. Comparison of cumulative percentages of Sullivan-Rozen flake categories: a) patterned-tool assemblages; b) core-reduction assemblages.

toward the production of flakes that could be used as blanks to produce small bifacial dart points. The material is described as fine-grained, and although the percussor type is not described, it is likely that it was either a hard hammer or large soft-hammer billet (cf. Tomka 1989:140). Prentiss and Romanski used a quartzite cobble hard hammer on fine-grained chert for both their spheroid and block cores, and the goal of reduction was to produce flake blanks for end-scraper production (Prentiss and Romanski 1989:90). Core dimensions are not given, but they do mention that the Morrison Formation chert used in their experiments contained inclusions and incipient fracture planes (Prentiss and Romanski 1989:90), and these could have contributed to the larger amounts of nonorientable fragments in their core assemblages.

The differences between the waste-flake assemblages produced by reduction of a flake blank and those produced by reduction of chert nodules are more easily explained as a result of differences in percussor type, original core form (i.e., flake blank versus nodule), and degree of refinement in the final end product. Tomka (1989:139-140) alludes to this in his own study, explaining that the use of pressure-flaking tools and soft-hammer percussors probably resulted in greater amounts of complete flakes than the use of a heavy billet during nodule or core reduction. Prentiss and Romanski used quartzite cobble hard hammers to reduce their chert nodules to Callahan's (1979:37) stage 3 form with flake scars "removed from the edge to approximately the center of the biface" (Prentiss and Romanski 1989:90). Thus, their bifaces were much less refined than Tomka's and no late-stage, soft-hammer percussion or pressure flaking was conducted.

The criticism of the Sullivan-Rozen typology by Mauldin and Amick (1989) is based on the degree of variability they observed in the proportional representation of complete and broken flakes between their three biface waste-flake assemblages. To an extent their criticisms are valid; however, they are based on the comparison of individual assemblages resulting from a single kind of lithic-reduction activity -- bifaces made from chert nodules. The fact that each assemblage of flakes resulting from these individual reduction episodes produces slightly different proportions of complete and broken flakes should not really come as a surprise since a certain amount of variability should be expected between individual knapping episodes even when raw material, percussor, flintknapper, and final form are held constant. In a "real" archaeological context, the three flake assemblages resulting from biface production would most likely be mixed to form a single, homogeneous assemblage. This is demonstrated by Kuijt et al.'s (1995:Table 2) bipolar-core data. While there is a fair degree of variability in the proportional representation of different flake categories between individual experimental assemblages, both the mean proportions and the proportions calculated from the total frequencies are very similar, as a comparison of the data in Table 10 with Kuijt et al.'s mean values in their Table 2 demonstrates. Therefore, collapsing the data from each individual episode into a single, biface- reduction assemblage and comparing this to flake assemblages resulting from other similar composite assemblages resulting from different reduction strategies is more likely to approximate archaeological reality, and so is a more valid test of the Sullivan-Rozen typology. When this is accomplished, and their composite biface flake assemblage is compared to the core- reduction assemblages of Prentiss and Romanski (1989:Table 1), Tomka (1989:Table 1), and Kuijt et al. (1995:Table 2), significant differences are shown to exist between the biface and core-reduction assemblages (Table 11).

Experimental Data

In a review of previous experimental studies that have explored variation in the size and form of lithic waste flakes, Shott (1994:79) indicated that recent experiments support some, but not all, of Sullivan and Rozen's original assertions. He concludes that use of the typology needs to be justified before it can be used. The review presented here suggests that use of the Sullivan-Rozen typology is best suited for determining differences between major lithic-reduction strategies, particularly patterned-tool (bifaces and unifaces) versus core reduction. However, the range of variability exhibited by the results of previous investigators indicates that additional experimental research needs to be done.

Table 11 Results of Chi-Square test of independence between Mauldin and Amick's (1989:Table 3) composite biface waste-flake assemblage and the core-reduction flake assemblages of Prentiss and Romanski (1989:Table 1), Tomka (1989:Table 1), and Kuijt et al. (1995 Table 2).

Experiments	Complete		Proximal		Shatter[a]		Totals	
	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Mauldin & Amick Bifaces	499	40.21	141	11.36	601	48.43	1241	100.00
Prentiss & Romanski Cores[b]	23	23.00	18	18.00	59	59.00	100	100.00
Tomka Core	101	49.27	14	6.83	90	43.90	205	100.00
Kuijt et al. Bipolar Cores[b]	49	12.07	1	0.25	356	87.68	406	100.00

Chi-Square Results
M&A Bifaces vs. P&R Cores: $X^2 = 27.1761$, df = 2, $p = <.0001$
M&A Bifaces vs. Tomka Core: $X^2 = 7.6057$, df = 2, $p = .0223$
M&A Bifaces vs. Kuijt et al.'s Bipolar Cores: $X^2 = 197.7815$, df = 2, $p = <.0001$

[a] Includes medial-distal fragments and nonorientable fragments.
[b] Does not include "split" flakes.

Therefore, rather than accept uncritically the models of any of the previous researchers, experimental flake assemblages using Florida cherts were analyzed using the Sullivan-Rozen typology in an effort to refine its use for the present study.

Individual flakes within each of 15 experimental waste-flake assemblages were assigned to one of the four Sullivan-Rozen flake categories using the criteria outlined in Chapter 7. Table 10 provides frequency and percentage data for all 15 assemblages. The first goal was to determine if significant differences exist between flake assemblages resulting from different reduction strategies. The data from four major reduction strategies -- bifaces, unifaces, small cores, and large cores -- were combined (Table 12) and the cumulative percentages were calculated and plotted by flake category (Figure 22). The resulting Ogive curves indicate that while there is very little difference between flake assemblages resulting from biface and uniface tool production, both of these assemblages appear to differ from flake

Table 12. Comparison of flake-breakage patterns between different reduction strategies for 15 experimentally produced flake assemblages. All experimental assemblages were sifted through 6.4 mm hardware cloth prior to analysis

Experiments	Complete		Proximal		Medial-Distal		Non-Orientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Hafted Biface #1	61	53.98	24	21.24	27	23.89	1	0.88	113[a]
Hafted Biface #2	36	15.86	57	25.11	131	57.71	3	1.32	227[a]
Hafted Biface #3	13	36.11	7	19.44	15	41.67	1	2.78	36
Biface #4	89	37.24	50	20.92	96	40.17	4	1.67	239
Uniface #1	86	54.43	26	16.46	38	24.05	8	5.06	158[a]
Uniface #2	45	17.11	53	20.15	164	62.36	1	0.38	263[a]
Uniface #3	16	40.00	11	27.50	13	32.50	0	.00	40[a]
Large Core #1	13	21.67	1	1.67	43	71.67	3	5.00	60
Large Core #2	62	31.63	14	7.14	87	44.39	33	16.84	196
Large Core #3	2	15.39	0	.00	10	76.92	1	7.69	13
Small Core #1	13	65.00	3	15.00	4	20.00	0	.00	20
Small Core #2	26	44.07	9	15.25	21	35.59	3	5.09	59
Small Core #3	22	37.93	6	10.34	22	37.93	8	13.79	58
Small Core #4	12	25.53	6	12.77	14	29.79	15	31.91	47
Small Core #5	35	34.65	11	10.89	38	37.62	17	16.83	101

[a] Does not include "split" flakes.

Table 13. Summary Sullivan-Rozen data for experimental biface-, uniface-, and core-reduction waste- flake assemblages.

Experiments	Complete		Proximal		Medial-Distal		Non-Orientable		Totals[a]
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Bifaces	199	32.36	138	22.44	269	43.74	9	1.46	615
Unifaces	147	31.34	90	19.52	215	46.64	9	1.95	461
Large Cores	77	28.63	15	5.58	140	52.05	37	13.75	269
Small Cores	108	37.89	35	12.28	99	34.74	43	15.09	285

[a] Does not include "split" flakes.

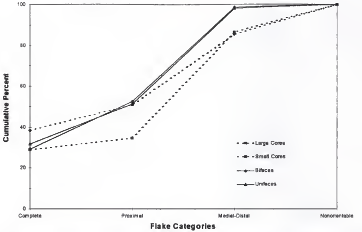


Figure 22. Comparison of cumulative percentages of Sullivan-Rozen flake categories for experimentally produced biface, uniface, and core assemblages.

Table 14. Kolmogorov-Smirnov test of cumulative flake frequencies between different reduction strategies. Significant differences ($p \leq .05$) are indicated by plus signs; minus signs indicate no significant differences.

Assemblages	Bifaces	Unifaces	Large Cores	Small Cores
Bifaces	---	–	+	+
Unifaces		---	+	+
Large Cores			---	+
Small Cores				---

assemblages resulting from the reduction of both small and large cores. Large-core reduction appears to result in significantly fewer proximal flakes and more nonorientable fragments than assemblages resulting from patterned-tool production (i.e., bifaces and unifaces). On the other hand, the small-core assemblages tend to have more complete flakes as well as more nonorientable fragments. The small-core and large-core assemblages appear to differ most in terms of the relative proportions of complete flakes, proximal flakes, and medial-distal fragments with the reduction of small cores resulting in more of the first two flake types. In order to test these observations statistically, a series of Kolmogorov-Smirnov tests of significance was conducted (Table 14). These pair-wise comparisons of different reduction assemblages confirm that there is little significant difference between flake assemblages resulting from biface and uniface production, and the results are similar to those of Prentiss and Romanski (1989) and Ingbar et al. (1989). The inability to distinguish consistently between biface and uniface flake assemblages also has been demonstrated by Austin and Jackson (1983) using an independent set of variables. Table 12 also indicates that both small- and large-core flake assemblages differ significantly from biface and uniface flake assemblages. These results also are in accord with those of Prentiss and Romanski, as well as those of Ingbar et al. (1989) who conducted a similar comparison of flake assemblage data from different reduction strategies.

These results suggest that the Sullivan-Rozen typology is not useful for determining between biface and uniface flake assemblages, and thus the two can be combined into a single "patterned-tool" assemblage for comparison with core- reduction assemblages. Further, the distinction between small-core and large-core reduction strategies appears to be an important one. The large proportion of complete flakes in the small-core assemblage may be the result of using a smaller, lighter percussor to remove flakes suitable for immediate use rather than large, heavy, hard hammers to remove large, comparatively thicker, flakes that can be further reduced into patterned tools. It also could be due to collection bias in that many of the broken flakes and nonorientable fragments produced during core reduction are actually "shatter" resulting from high-impact blows to the core platform. In large-core reduction, this "shatter" material tends to be relatively large while in small-core reduction it can be quite small. Many of the broken flakes produced during small-core reduction may not have been collected when the assemblage was sifted through the 6.4 mm screen, an inference that is partly substantiated by the large number of flakes retained in the 1.6 mm size fraction (see discussion on flake-size distribution below). As a result, the complete flake total may be artificially inflated.

Multivariate Classification

To evaluate the usefulness of the Sullivan-Rozen typology for distinguishing between patterned-tool- and core-reduction assemblages, the 15 experimental flake assemblages were subjected to discriminant-function analysis (see Chapter 7 for a discussion of this technique). The purpose of using this multivariate classification technique was to derive an objective means of assigning archaeological assemblages to either a patterned-tool- or core-reduction strategy using the Sullivan-Rozen flake categories.

The 15 experimental flake assemblages were first divided into three groups -- patterned-tool, large-core, and small-core assemblages -- based on an independent criterion, the a priori knowledge of their origins. It was hoped that the distinction between the three types of experimental assemblages observed in the Ogive curves and confirmed by the Kolmogorov-Smirnov tests would be great enough to enable multivariate discrimination to be made, and so enable archaeological assemblages to be similarly distinguished.

Table 15 shows the results of this discrimination attempt. These results indicate that when a three-group separation is used, the discriminant-function analysis correctly classifies 86.67 percent of the experimental assemblages. One of the patterned-tool flake assemblages (a biface) and one of the large-core flake assemblages were missassigned to the small-core group. While this high success rate was encouraging, the fact that one of the large-core flake assemblages was was missassigned to the small-core group suggested that a more successful discrimination could be achieved with a two-group separation. The results of this second discrimination attempt are shown in Table 16. As expected, the discrimination between the patterned-tool and combined core groups is better with 93.33 percent of the experimental assemblages correctly classified.

Table 15. Three-way classification of experimental patterned-tool- and core-reduction debitage assemblages.

From Group	Into Group			Totals
	Patterned Tools	Large Cores	Small Cores	
Patterned Tools	6	0	1	7
	85.71%	.00%	14.29%	100.00%
Large Cores	0	2	1	3
	.00%	66.67%	33.33%	100.00%
Small Cores	0	0	5	5
	.00%	.00%	100.00%	100.00%
Totals	6	2	7	15
	40.00%	13.33%	46.67%	100.00%
Priors	46.67%	20.00%	33.33%	100.00%

Percent of cases correctly classified: 86.67%

Table 16. Two-way classification of experimental tool and core debitage assemblages.

From Group	Into Group		Totals
	Patterned Tools	Cores	
Patterned Tools	6	1	7
	85.71%	14.29%	100.00%
Cores	0	8	8
	.00%	100.00%	100.00%
Totals	6	9	15
	40.00%	60.00%	100.00%
Priors	46.67%	53.33%	100.00%

Percent of cases correctly classified: 93.33%

A final test was conducted to determine if flake assemblages resulting from bipolar-core reduction could be discriminated from patterned-tool and conventional core flake assemblages. The ability to make this distinction became apparent during analysis of archaeological assemblages from several sites in the study collection where evidence of bipolar reduction was present. Since chert nodules or cobbles are rare in Florida, I included the Sullivan-Rozen data from nine bipolar core-reduction flake assemblages published by Kuijt et al. (1995:Table 2) in the test. A three-group classification was attempted which compared flake assemblages from patterned-tool, conventional core, and bipolar-core reduction. The results are presented in Table 17 which shows that 95.83 percent of the assemblages was correctly classified. The discrimination between bipolar-core and conventional core assemblages was perfect; the only missassigned assemblage was the biface assemblage previously missassigned to the small-core group. Examination of the data in Table 10 indicates that this assemblage contained a relatively low number of proximal fragments, and although only one nonorientable fragment is present, it accounts for nearly 3 percent of this small assemblage. A bivariate plot is provided in Figure 23 which shows that the assemblages comprising the three groups (tools, conventional cores, and bipolar cores) are fairly well separated with minimal overlap.

These results are certainly encouraging, but they are somewhat artificial in that the individual assemblages represent single reduction episodes of one tool or core type. While the use of these assemblages provides an important element of experimental and analytical control, they do not reflect a typical archaeological assemblage which often includes debitage from more than one reduction episode and may include debitage from several different reduction strategies. To evaluate the effectiveness of discriminant analysis to correctly classify such a mixed assemblage, three simulated assemblages were developed and subjected to discriminant classification. The simulated assemblages were generated using the following procedure. First, an assemblage size of 200 flakes was assumed. Then, the proportional representations of the four Sullivan-Rozen flake categories for composite patterned-tool- and core-

Table 17. Three-way classification of experimental patterned-tool- and core-reduction debitage assemblages.

From Group	Into Group			Totals
	Patterned Tools	Cores	Bipolar Cores[a]	
Patterned Tools	6	1	0	7
	85.71%	14.29%	.00%	100.00%
Cores	0	8	0	8
	.00%	100 00%	.00%	100.00%
Bipolar Cores[a]	0	0	9	9
	100.00%	100.00%	100.00%	100.00%
Totals	6	9	9	24
	25.00%	37.50%	37.50%	100.00%
Priors	29.17%	33.33%	37.50%	100.00%

Percent of cases correctly classified: 95.83%

[a] Data from Kuijt et al. 1995:Table 2.

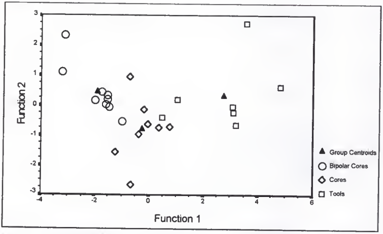


Figure 23. Plot of discriminant-function scores for experimental flake assemblages resulting from patterned-tool, conventional core, and bipolar-core reduction.

Table 18 Summary Sullivan-Rozen data for experimental patterned tool (biface and uniface), experimental core (large and small) reduction, and simulated mixed (patterned tool and core) waste-flake assemblages.

Waste-Flake Assemblages	Complete		Proximal		Medial-Distal		Non-Orientable		Totals[a]
	N	p	N	p	N	p	N	p	
Patterned Tools	257	.307	178	.213	388	.464	14	.017	837
Cores	185	.334	50	.090	239	.464	80	.144	554
Mixed (75:25)	63	.315	37	.185	90	.450	10	.050	200
Mixed (50:50)	64	.320	30	.150	89	.445	17	.085	200
Mixed (25:75)	65	.325	24	.120	88	.440	23	.115	200

[a] Does not include "split" flakes.

reduction assemblages were calculated (Table 18). Using these proportions, three hypothetical assemblages were simulated mathematically with each assemblage representing a different ratio of patterned-tool- and core-reduction debitage: 75:25, 50:50, and 25:75. The formula used to simulate these mixed assemblages is:

$$S = \sum (A * p_r) * p_c$$

where S = a simulated assemblage of flakes within a specified Sullivan-Rozen debitage category, A = assemblage size, p_r = the desired proportional representation of flakes to be derived from a specified reduction strategy, and p_c = the proportional representation of flakes within a specified Sullivan-Rozen debitage category. So, for a hypothetical assemblage of 200 flakes consisting of 75 percent tool-reduction debitage and 25 percent core-reduction debitage, and using the proportions in Table 18, the following values would be inserted into the equation to determine the number of Complete flakes:

$$S_{(complete)} = \sum ([200 * .75] * .307) + ([200 * .25] * .3339) = 63$$

This procedure was followed for each debitage category to create the three simulated assemblages in Table 18. These values were then subjected to discriminant analysis and the resulting bivariate plot is

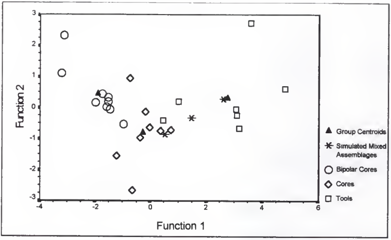


Figure 24. Plot of discriminant-function scores for experimental and simulated waste-flake assemblages.

presented in Figure 24. The only simulated assemblage that was assigned to the core-reduction group is the one that consists of 75 percent core-reduction debitage; the other two were assigned to the patterned-tool group. However, examination of Figure 24 shows a general pattern of decreasing similarity with the patterned-tool group as the proportion of core-reduction debitage increases in the simulated assemblages. The simulated assemblage that consists of a 50:50 mix of debitage from the two reduction strategies occupies an intermediate position between the other two simulated assemblages, and it also is intermediate between the group centroids for patterned tools and cores.

What this exercise suggests is that archaeological assemblages composed of a mix of waste flakes resulting from patterned-tool- and core-reduction strategies are likely to be classified as belonging to the patterned-tool group if the representation of core-reduction debitage is 50 percent or less. It is possible to infer a mixed assemblage based on the positioning of the assemblages on a bivariate graph such as that in Figure 24, and this inference can be tested by examining other debitage attributes such as platform angle, platform condition, or dorsal scar orientation (cf. Austin 1995b).

Summary

Three methods were used to interpret the experimental Sullivan-Rozen data. A graphic presentation of cumulative percents, a pair-wise Kolmogorov-Smirnov test of significance, and discriminant-function analysis. Each method indicated significant differences between flake assemblages produced by patterned-tool production and those produced by core reduction. The graphic presentation of cumulative percents also indicates that small-core and large-core reduction strategies can be discerned using this method. Using a three-group separation for the discriminant-function analysis produces acceptable results (over 86 percent correct assignments). However, a more reliable classification is achieved using only a two-group separation with maximum discrimination occurring between patterned-tool- and core-reduction assemblages. When Kuijt et al.'s bipolar-core-reduction data were added to the discriminant analysis, and a new three-group separation was attempted, the success rate proved to be quite high, with over 95 percent of the experimental assemblages correctly assigned.

These results indicate that the Sullivan-Rozen typology can be used successfully to distinguish between flake assemblages resulting from the reduction of patterned tools and those resulting from the reduction of cores. Furthermore, in situations where bipolar-core reduction is suspected, the Sullivan-Rozen typology can be used to distinguish between conventional-core- and bipolar-core-reduction strategies. Table 19 provides the discriminant-function coefficients for the two most successful discriminations: the two-group separation without bipolar cores and the three-group separation with bipolar cores. These coefficients can be used to classify archaeological assemblages of unknown origin by summing the products of the frequency values for each flake category multiplied by the appropriate coefficient.

Table 19. Discriminant-function coefficients for two-group and three-group separations of experimental debitage.

Variables	2-Group Separation	3-Group Separation	
	Function 1	Function 1	Function 2
Complete	.0158744	.0263414	-.0483061
Proximal	.0950758	.0904952	.1894394
Medial-Distal	-.0182204	-.0160365	-.0468301
Nonorientable	-.0717370	-.0776741	.1025866

While the Kolmogorov-Smirnov and discriminant-function analyses provide the least subjective means of distinguishing between the various reduction strategies, it appears that discriminant function is less successful for distinguishing between small- and large-core-reduction strategies. Therefore, the use of discriminant-function analysis in conjunction with cumulative percentage (Ogive) curves and/or the Kolomogrov-Smirnov test of significance appears to be the most fruitful way of utilizing the Sullivan-Rozen typology.

Simulated assemblages consisting of different mixtures of patterned-tool- and core-reduction debitage were classified using the discriminant-function procedure. This exercise indicated that caution needs to be exercised when using this method for interpreting archaeological assemblages since an assemblage containing as much as 50 percent core-reduction debitage can be classified as belonging to the patterned-tool group. However, as might be expected, such an assemblage occupies an intermediate position on a bivariate graph of the discriminant-function scores, and this positioning, along with the statistical probability of membership that is provided by most discriminant-function programs, can provide the analyst with some clues as to the potential for a mixed assemblage to be present. If a mixed assemblage is suspected, then this can be tested using other debitage attributes.

Flake-Size Distribution

Previous Experiments and Applications

The sizes of waste flakes have been used for some time in lithic analysis to infer reduction stages in biface manufacture. Experimental data have repeatedly confirmed the commonly held assumption that the further one proceeds in the biface-reduction continuum, the smaller the resulting debitage becomes (Henry et al. 1976; Mauldin and Amick 1989; Newcomer 1971; Patterson 1981, 1982; Patterson and Sollberger 1978). More recent studies have attempted to use flake-size distributions to distinguish between different reduction strategies, specifically biface reduction versus core reduction (Ahler 1989a; Baumler and Downham 1989; Behm 1983; Patterson 1990; Tomka 1989). This kind of application of flake-size data has its basis in geology and soils science, where the analysis of grain-size distributions are a standard technique for both describing and determining the origins of various geological sediments (e.g., Bagnold and Barndorff-Nielsen 1980; Ibbeken 1983). Shott (1994) has reviewed most of the major experimental studies related to the examination of flake-size in lithic reduction.

For some forms of analysis, the recording of individual measurements for each flake is a necessity; however, when confronted by flake assemblages that often number in the thousands or even tens of thousands, the chore of recording metric data for individual flakes can be probibitively time-consuming. An alternative to this approach is the use of size-sorting techniques that attempt to quickly partition entire assemblages according to size or weight classes.

The use of nested screens of various size grades is one approach pioneered by Ahler (1989a, 1989b; see also Baumler and Downham 1989; Behm 1983; Schick 1986, Stahle and Dunn 1982, 1984) and is often referred to as "mass analysis." The flakes retained in each size grade can then be weighed or counted and the resulting data for each size grade are plotted to produce distribution curves. An alternative approach is to simply fit individual flakes into grids of different sizes (e.g., 1 cm, 2 cm, etc.) and then weigh and/or count the number of flakes within each size class (cf. Patterson 1990).

Regardless of which of these size-sorting techniques is used, all of the experimental studies indicate that lithic reduction results in flake-size distributions that are exponential in form; that is, more small flakes are produced than large flakes regardless of the reduction strategy or stage of reduction (e.g., Behm 1983; Patterson 1990; Schick 1986; Stahle and Dunn 1982, 1984; Tomka 1989). Correspondingly, flake weight (i.e., the average weight per size grade) tends to decrease exponentially (Ahler 1989b). As Shott (1994:90) points out, these results in and of themselves, are trivial. However, experimentation also has revealed that the flake-size distributions resulting from different types of lithic-reduction strategies can differ in form and slope, and this can provide the analyst with a potentially powerful tool for analyzing lithic waste-flake assemblages from archaeological sites.

Using flake-size data from the replication of several hafted bifaces, Stahle and Dunn (1982) compared the resulting cumulative frequency distributions to a number of different theoretical distributions They concluded that the Weibull distribution, most often used to analyze fractured materials, best fit their biface flake-assemblage data. Furthermore, they demonstrated that successive stages of biface reduction yielded increasingly greater slope coefficients (Stahle and Dunn 1982:89, 1984 Figure 3). Based on the results of their analyses, they suggested that the Weibull distribution might be distinct to biface reduction and that other reduction strategies might be best characterized by different distributions (Stahle and Dunn 1984.13). However, when flake assemblages resulting from core reduction and scraper reduction were compared to the Weibull, exponential, log-linear, and extreme-value distributions by Shott (1994:96-97), both types of assemblages were found to fit all of the distributions equally well. Shott (1994 97) concluded that the Weibull distribution was not unique to biface reduction alone, and cautioned against its general use

Patterson (1981, 1982, 1990; Patterson and Sollberger 1978) has developed a model of biface reduction based on the log-linear distribution of flake sizes. Using simple frequency data from 14 biface replications, Patterson (1990:Figure 1) found that the resulting flake-size distributions were exponential in form (Figure 25a). When the percentage data were transformed using a semilog-linear equation, the biface-reduction data yielded a relatively straight-line distribution (Figure 25b; cf. Patterson 1990:Figure 3). Patterson also compared the biface assemblage distribution to flake-size distributions resulting from core reduction and found the latter to be irregular in shape when plotted as simple proportions (Patterson 1990:Figure 2). Based on these results, Patterson (1990:551) claimed that the concave-curved, exponential shape (or its semilog equivalent) was unique to biface reduction, and that core-reduction assemblages can be differentiated from biface-reduction assemblages by their more irregular distribution patterns.

Although the experiments cited above have confirmed the exponential nature of flake assemblages resulting from biface reduction, they have failed to confirm the irregular core-reduction pattern (cf., Baumler and Downham 1989; Behm 1983; Tomka 1989; and see the review in Shott 1994). When the core-reduction flake-size data from these studies are plotted they all yield concave, exponential curves (Figure 26a, c). Moreover, the slopes of the biface-reduction curves tend to be steeper than the core-reduction curves, and more advanced stages of biface reduction yield steeper curves than less advanced stages (Figure 26b). When the log transforms of these data are used and plotted on a log-linear graph, similar results are obtained (cf. Shott 1994:92-93). These comparisons confirm the observations of Stahle and Dunn (1982, 1984) regarding the increase in the slope coefficients of flake-size distributions produced during more advanced stages of biface reduction, and add to these by verifying that core reduction also can be distinguished by variation in slope.

It is unclear why Patterson's core-reduction experiments yielded such irregular distributions. It is possible that he removed certain flakes for further use in biface or other patterned-tool replication

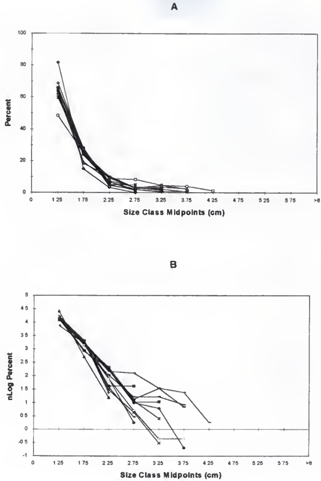


Figure 25. The "Patterson Curve" illustrating a) the exponential form of flake-size distributions resulting from biface reduction, and b) the straight-line distribution that results from using logarithmic transforms (data from Patterson 1990:Table 1).

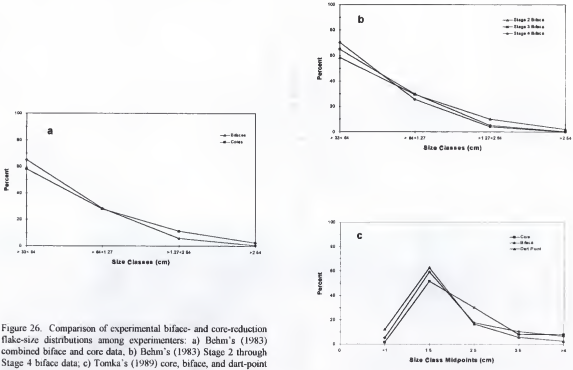


Figure 26. Comparison of experimental biface- and core-reduction flake-size distributions among experimenters: a) Behm's (1983) combined biface and core data, b) Behm's (1983) Stage 2 through Stage 4 biface data; c) Tomka's (1989) core, biface, and dart-point data.

experiments which would have biased the size distribution of the remaining assemblage (Prentiss 1991). Shott (1994:94) also seems puzzled by this discrepancy. Despite the acknowledged simplicity and elegance of Patterson's model, the fact that other reduction strategies consistently produce exponential (or log-linear) flake-size distributions seems to have discouraged Shott regarding the usefulness of Patterson's log-linear model (Shott 1994:94). This is unfortunate because the log-linear model is perhaps the simplest to use and, as demonstrated by the data in Figure 26, does yield interpretable results.

Experimental Results

Testing the "broken stick" model. It is clear from a review of these previous studies that the approach that has been followed is to "discover" a model that best describes the distribution of flake size that is specific to the particular circumstances of the individual studies. In other words, the experimental studies have focused on pattern recognition rather than the testing of a general theoretical model. Research in a wide variety of fields indicates that the size distributions of many natural phenomena result in an exponential distribution similar to those exhibited by waste-flake assemblages (Epstein 1947; Ibbeken 1983). This has been referred to as the "broken-stick" phenomenon (e.g., Raup 1991:58-60). Thus, while Patterson's analyses suggest that the large numbers of small flakes resulting from biface manufacture are characteristic of that reduction strategy, the results of other experimenters indicate that this exponential pattern is instead a natural result of the fracture mechanics of a brittle solid. Each detachment blow produces not only a flake or flakes of a predetermined size and/or shape, but many smaller fragments as well.

This natural tendency towards an exponential size distribution can be easily tested by a simple experiment. Five fragments of chert of different types each were subjected to 25 random blows using a steel rock-hammer. The individual chert fragments were double-bagged in 6 mil, zip-lock, plastic bags which were than placed in a pillow case. This kept chert fragments from spraying around the room and ensured that all fragments would be collected. The resulting debitage was sifted through 1.6 mm-mesh hardware cloth and placed in .5 cm size classes using the grid system described in Chapter 7 (cf. Patterson 1990). The resulting data, including sizes of original chert pieces, are presented in Table 20 and the flake-size distributions are shown in Figure 27. As this figure demonstrates, the random fracturing of chert produces distribution curves that are similar in form to those resulting from patterned-tool or core reduction.

These results indicate that the exponential distribution is not characteristic of any single reduction strategy, but is instead typical of all modes of fracture of siliceous material. The range of raw materials used in the experiment also indicates that while some variation may be present between materials that are more brittle than others, the general shapes of the distribution curves vary only slightly. Returning to the experimental work of other archaeologists, it is apparent that the insights of Stahle and Dunn (1982, 1984) regarding variation in the slopes of the linearized flake-size distributions of different stages of biface reduction, provides a potentially useful methodological tool for distinguishing between different reduction strategies. Thus, the next step in my experimental program was to determine if flake assemblages resulting from patterned-tool and core reduction could be recognized consistently using linearized flake-size distribution data.

Core reduction versus patterned-tool reduction. The debitage resulting from the 15 experiments described previously were individually placed in one of the .5 cm flake-size grids as was done for the randomly fractured chert pieces. The only difference was that flakes that did not pass through a 6.4 mm screen were not used in the flake-size analysis. There were three reasons for this. First, most lithic assemblages from archaeological sites are collected using 6.4 mm-mesh hardware cloth, so to be com-

Table 20 Flake-size data for random-fracture experiments.

Size Classes (cm)	Exp. 1		Exp. 2		Exp. 3		Exp. 4		Exp. 5	
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
< .5	28	77.93	587	85.32	619	71.31	355	67.62	1401	77.75
.5-1	50	13.62	48	6.98	153	17.63	108	20.57	286	15.87
1-1.5	15	4.09	29	4.22	50	5.76	32	6.10	68	3.77
1.5-2	4	1.09	13	1.89	17	1.96	14	2.67	17	.94
2-2.5	2	.54	7	1.02	9	1.04	10	1.90	8	.44
2.5-3	4	1.09	1	.15	8	.92	4	.76	8	.44
3-3.5	3	.82	3	.44	2	.23	2	.38	5	.28
3.5-4	1	.27	0	.00	0	.00	0	.00	4	.22
4-4.5	1	.27	0	.00	3	.35	0	.00	1	.06
4.5-5	0	.00	0	.00	2	.23	0	.00	1	.06
5-5.5	0	.00	0	.00	2	.23	0	.00	2	.11
5.5-6	0	.00	0	.00	1	.12	0	.00	1	.06
> 6	1	.27	0	.00	2	.23	0	.00	0	.00
Totals	367	100.00	688	100.00	868	100.00	525	100.00	1802	100.00

Experiment 1: Ocala Quarry Cluster chert, 74.6 mm x 85 mm x 48.2 mm
Experiment 2: Peace River Quarry Cluster chert, 80.6 mm x 67.2 mm x 34.8 mm
Experiment 3: Ocala Quarry Cluster chert, 147.3 mm x 120.4 mm x 57.4 mm
Experiment 4: Hillsborough River Quarry Cluster chert, 84.3 mm x 59.8 mm x 38.1 mm
Experiment 5: Peace River Quarry Cluster chert, 104.5 mm x 111.7 mm x 84.5 mm

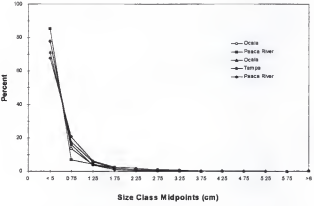


Figure 27. Plot of flake-size distributions for randomly fractured chert.

parable, the experimental distributions should be based on a similar collection strategy. Second, it was not possible to simply eliminate all flakes that were placed in size classes less than 1 cm because flakes smaller than this size threshold often are retained in a 6.4 mm screen. This is one reason why the flake-size distributions of Tomka (1989:Figure 5) differ from those of Patterson (1990:Figures 1 and 3). Patterson did not include flakes smaller than 15 mm (1.5 cm) while Tomka screened his assemblages through 6.4 mm mesh and so retained some smaller flakes. Finally, the flake assemblages from archaeological sites in my study area are typically small in size, both in terms of total numbers of flakes and specimen dimensions. Eliminating from consideration flakes smaller than 1 cm would eliminate anywhere from 20-50 percent of all debitage from some sites or site components. Therefore, I felt it necessary to have experimental flake assemblages that would approximate those that would likely be found in archaeological assemblages in my study area. While this results in a deviation from linearity at the small end of the size distribution, it does not affect significantly the characteristic slopes of the size distributions, as will be demonstrated below. Nor does collapsing all flakes larger than the 6 cm size class into a single size class (i e., flakes > 6 cm) adversely affect the resulting slopes.

The raw data on flake size for the 15 experimental assemblages are provided in Table 21. Figure 28 graphically compares the distributions of the individual biface and uniface flake assemblages. Figure 29 provides a similar comparison of the distributions of individual core-reduction flake assemblages. As these figures demonstrate, there is a high degree of similarity in the size distributions of flake assemblages produced from biface and uniface production; however, the uniface assemblages do tend to have slightly fewer flakes in the smallest size classes. The small- and large-core flake assemblages also exhibit very close correspondence. In Figure 30, the flake-size data from individual experiments have been collapsed to create two composite flake assemblages -- biface and core reduction -- and these are compared in both their exponential and log-linear forms. The biface assemblage consists of debitage from the replications of Bifaces 1, 2, and 3 in Table 20. Debitage from biface replication number 4 was not included in the biface control group because no late-stage debitage was created during this replication and so the full range of biface-reduction debitage was not present. The debitage resulting from uniface production also was not included in the composite flake assemblage because the slightly flatter curves exhibited by the uniface production debitage in Figure 28 suggested that it might be possible to distinguish this reduction strategy from biface and core reduction. Comparison of the early-stage biface and uniface-production flake assemblages with the biface and core-reduction assemblages is discussed below.

The flake-size distributions in Figure 30 indicate that proportionately more small flakes are produced during biface production that during core reduction. Other significant patterns are the greater proportions of flakes in the 1.5-2 cm size class for cores versus patterned tools and the longer "tails" on the right-hand side of the distribution for core-reduction assemblages Both of these are indicative

Table 21. Flake-size data for experimental tool and core replications. All assemblages sifted through 6.4 mm screens.

Size Classes (cm)	Bif. 1	Bif. 2	Bif. 3	Bif. 4	Uni 1	Uni. 2	Uni. 3	LC 1	LC 2	LC 3	SC 1	SC 2	SC 3	SC 4	SC 5
<1	32	42	7	41	33	26	6	10	28	1	4	12	9	13	25
1-1.5	61	106	19	89	62	101	26	11	66	4	4	19	19	14	26
1.5-2	16	35	3	65	34	49	6	11	44	4	4	10	12	9	21
2-2.5	4	25	5	19	11	28	4	10	19	1	2	6	5	4	9
2.5-3	1	13	2	17	12	24		5	6	1	1	4	4	2	7
3-3.5	1	4		4	6	10		3	12	0	2	3	2	2	2
3.5-4		6		3	0	5		1	4	1	0	2	2	0	1
4-4.5		2		1	0	10		2	3		0	3	1	2	3
4.5-5		2			2	6		3	2		1		2	0	1
5-5.5					0	2		0	4		2		1	0	3
5.5-6					1	4		1	3				0	1	0
>6						2		3	4	1			1		3
Totals	115^a	235^a	36	239	161^a	267^a	42^a	60	196	13	20	59	58	47	101

KEY: Bif. = Biface; Uni. = Uniface; LC = Large cores; SC = Small cores.

^{a} Totals include "split" flakes.

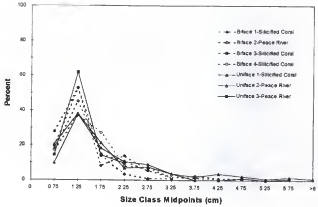


Figure 28. Comparison of flake-size distributions for bifaces and unifaces.

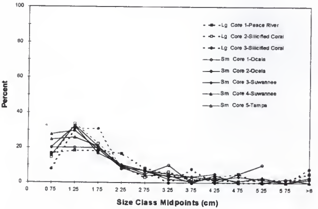


Figure 29. Comparison of flake-size distributions for core-reduction assemblages.

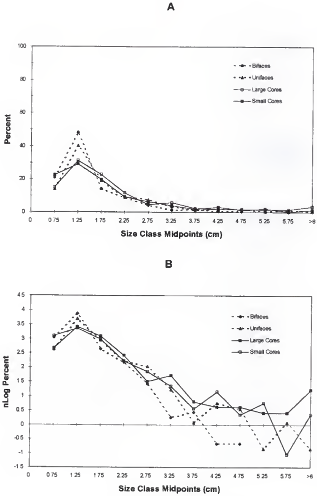


Figure 30. Comparison of flake-size distributions for composite biface- and core-reduction assemblages: a) exponential; b) log-transformed.

of the tendency for core reduction to create more flakes in the larger size classes. This tendency is due to the different goals of the two reduction strategies. The goal of biface production is to reduce a large piece of material into a smaller, patterned shape. Since the size of the "core" becomes increasingly smaller, flake removals also become smaller as the production trajectory continues. On the other hand, core reduction often is geared towards producing flakes that can be used as blanks for further reduction into patterned tools or for immediate use as expedient tools. Regardless of which of these is the intended goal, flake removals tend to be directed towards the maximum size possible given the constraints of overall core size (cf. Schick 1986:23; Tomka 1989:145).

Modeling assemblage variability. As with the Sullivan-Rozen data, the probability that one will encounter an archaeological assemblage that is the result of only a single reduction strategy is probably small. In order to evaluate how different assemblage compositions might be interpreted using flake-size data, several different flake assemblages were compared to the experimental biface- and core-reduction assemblages. Two of these assemblages were composed of debitage that resulted from experimental replications not used in the biface and core control assemblages. These assemblages include the debitage resulting from Biface Replication #4 and the three uniface replications (Table 20). In addition to these experimental assemblages, five simulated assemblages were created using the method described previously for the Sullivan-Rozen analysis. Again, assemblage size was assumed to equal 200. Three simulations created assemblages that included increasingly greater ratios of core-reduction debitage to biface-production debitage: 75:25, 50:50, and 25:75. Two simulations created assemblages that included 75 percent and 50 percent biface-reduction debitage and 25 percent and 50 percent small-core-reduction debitage. The small-core flake-size data used to generate these simulated assemblages was derived from Small Core #1 and Small Core #2 (see Table 20). These core-reduction assemblages were used because they do not contain as many large flakes as the other core-reduction assemblages and so might be a more accurate reflection of the type of core-reduction assemblages that would be encountered in the archaeological study collections. The flake-size data for these five simulated assemblages are presented in Table 22.

Figure 31 graphically compares the early-stage biface and uniface flake assemblages with the biface and core control assemblages. As this figure shows, both of these flake assemblages exhibit linearized distribution curves that are somewhat intermediate between the experimental biface and core-reduction curves. The flake assemblage resulting from early-stage biface production (Figure 31a) exhibits fewer flakes in the smallest size classes than the flake assemblage resulting from the full range of biface-reduction activities, yet there are more small flakes than in the core-reduction flake assemblage. The right side of the early-stage biface flake distribution closely parallels the experimental biface assemblage curve and this provides a clue to identifying the correct reduction strategy. On the other hand, the uniface flake assemblage distribution is very similar to the flake-size distribution for experimental core-reduction except that there are more flakes in the 1-1.5 cm size class (Figure 31b). This close similarity between the flake-size distributions for the two reduction strategies suggests that it would be difficult to distinguish between them in an archaeological assemblage.

The simulated assemblages are compared to the control assemblages in Figures 32 and 33. These comparisons indicate that small amounts of core-reduction debris in a flake assemblage that is predominately the result of biface reduction has little effect on the overall assemblage composition (Figures 32a and 33a). In other words, it would be difficult to identify that core-reduction has occurred on the basis of flake-size data alone. As core-reduction becomes more frequent and contributes greater and greater amounts of waste flakes to the debitage assemblage, the ability to identify core-reduction activities increases. The area of the distribution curve that appears to be the most diagnostic of this activity is the right side where larger flakes gradually increase in abundance as the contribution of core-reduction debitage increases (Figures 32b-c and 33b).

Table 22. Flake-size data for simulated assemblages.

Size Classes (cm)	Mixed Biface-Core			Mixed Biface-Small Core	
	75/25	50/50	25/75	75/25	50/50
<1	41	39	38	42	41
1-1.5	87	78	68	87	77
1.5-2	31	35	38	30	32
2-2.5	18	19	20	18	19
2.5-3	9	10	10	9	10
3-3.5	4	6	8	5	8
3.5-4	3	4	4	4	4
4-4.5	2	3	4	3	4
4.5-5	2	2	3	1	2
5-5.5	1	2	3	1	3
5.5-6	0	1	1		
>6	7	2	4		
Totals[a]	199	201	201	200	200

[a] Not all totals equal 200 due to rounding errors.

Statistical comparison of slopes. The difference in slope between the core-reduction flake assemblage and the biface-production flake assemblage is clear in Figure 30; the biface flake distribution has a steeper slope reflecting the greater proportion of small flakes. Fitting regression lines to the flake-size data for the two assemblages (Figure 34) enables a statistical calculation of slope. Note that for this analysis the midpoints of the various size classes are used in the regression calculation. For the smallest (<1) and largest (>6) size classes midpoint values of .75 and 6.25 are used.

For the biface flake assemblage $b = -1.15714$ while for the core flake assemblage $b = -.58324$. Comparing an archaeological assemblage to these control assemblages can be done visually, and in

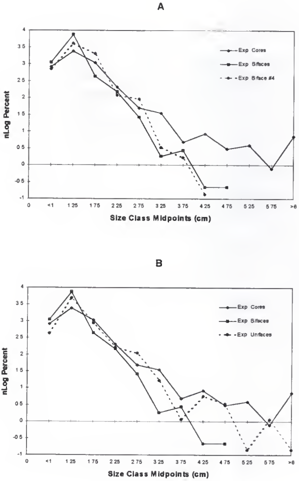
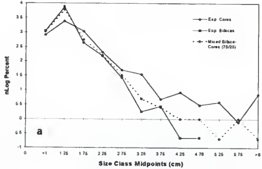
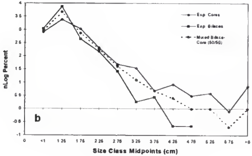


Figure 31. Comparison of flake-size distributions for early-stage biface and uniface-production assemblages with composite biface and core-reduction assemblages: a) early-stage biface assemblage; b) uniface assemblage.





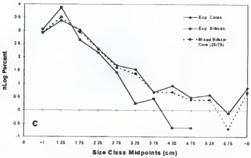


Figure 32 Comparison of flake-size distributions for simulated mixed biface and core-reduction assemblages with composite experimental biface and core-reduction assemblages: a) 75:25; b) 50:50; c) 25:75.

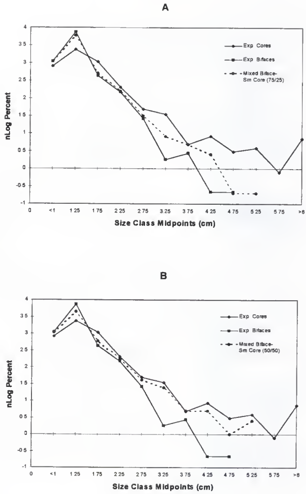


Figure 33. Comparison of flake-size distributions for simulated mixed biface and small-core-reduction assemblages with composite experimental biface and core-reduction assemblages: a) 75:25; b)50:50.

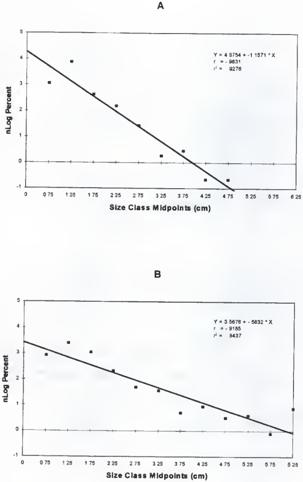


Figure 34. Regression lines fitted to log-transformed experimental flake assemblage data: a) biface reduction, b) core reduction

many cases this is sufficient to distinguish between biface production and core reduction. However, in situations where both reduction strategies have contributed to a debitage assemblage, or where different stages in a tool-production trajectory have occurred, the resulting flake-size distributions may be intermediate between the biface and core-reduction slopes. When this occurs, a more objective means of distinguishing between reduction strategies is desirable. This can be done using analysis of variance (ANOVA) following the procedures of Sokal and Rohlf (1981:499-509). The procedure is used to test the null hypothesis that two regression slopes are homogeneous; that is, that two samples came from populations with equal slopes (see Chapter 7 for a discussion of the formulae used to compare regression slopes). The procedure is demonstrated using the data from the core-reduction and biface-reduction assemblages (Table 23). The ANOVA results comparing the regression slopes of the two experimental flake assemblages are presented in Table 24. The *F* value of 17.3120 is significant at the .001 level. From this it is possible to conclude that the two assemblages came from populations with different slopes.

To illustrate application of the method, the early-stage biface, uniface, and simulated biface and core-reduction assemblages were subjected to the ANOVA analysis and the results are shown in Table 25. The ANOVA results indicate that the slope of the linearized early-stage biface flake-size distribution is significantly different from the experimental core-reduction assemblage, while the slope of the linearized uniface-reduction flake assemblage is significantly different from the experimental biface-reduction assemblage. These results are in accord with the visual interpretation of the data in Figure 31. The ANOVA results also provide fairly good discrimination between the simulated assemblages. All of the assemblages containing 50 percent or more of core-reduction debitage were determined to be significantly different from the experimental biface-reduction assemblage. However, discrepancy occurs with the two simulated assemblages that contain only small amounts of core reduction debitage. The assemblage consisting of a 75:25 ratio of biface and small-core reduction debris

Table 23. Raw data used in the calculation of regression lines and Analysis of Variance (ANOVA).

Size-Class Midpoints	Cores			Bifaces[a]		
	N	Pct.	nLog	N	Pct.	nLog
75	102	18.41	2.9130	81	20.98	3.0438
1.25	163	29.42	3.3818	186	48.19	3.8751
1.75	115	20.78	3.0329	54	13.99	2.6383
2.25	56	10.11	2.3134	34	8.81	2.1757
2.75	30	5.42	1.6892	16	4.15	1.4219
3.25	26	4.69	1.5461	5	1.30	.2588
3.75	11	1.99	.6859	6	1.55	.4411
4.25	14	2.53	.9271	2	.52	-.6575
4.75	9	1.62	.4852	2	.52	-.6575
5.25	10	1.81	.5906			
5.75	5	.90	-.1026			
6.25	13	2.35	.8530			

[a] Includes data from biface experiments 1-3; biface experiment #4 was not included because late-stage debitage (i.e., final thinning and shaping) was not represented in this assemblage.

Table 24. Results of Analysis of Variance testing the equality of slopes between experimental core-reduction and biface-reduction flake-size distributions.

Source of Variation	*df*	*SS*	*MS*	F_s
Among *b*'s	1	3.4802	3.4802	17.3120
Within *b*'s	19	3.8196	.2010	

Critical value of $F_{(1,19)}$ at an alpha level of .001 = 15.1

Table 25. Results of Analysis of Variance testing the equality of slopes between experimental and simulated flake assemblages. Bold entries indicate rejection of the null hypothesis of no difference between slopes.

Assemblage	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
		F	CV ∝ .05[a]	$b_{cores} - b_t$[b]	F	CV ∝ .05[a]	$b_{bifaces} - b_t$[b]
Experimental Biface #4	-1.2243	**13.4721**	**$F_{(1,18)}$ =4.41**	.6411	.1108	$F_{(1,15)}$ = 4.54	.0672
Experimental Unifaces	-.7743	2.6606	$F_{(1,22)}$ = 4.30	.1911	**6.2441**	**$F_{(1,19)}$ =4.38**	.3828
Mixed Biface-Core (75:25)	-.8019	3.8626	$F_{(1,22)}$ = 4.30	.2187	**6.0564**	**$F_{(1,15)}$ =4.54**	.3552
Mixed Biface-Core (50:50)	-.7496	2.599	$F_{(1,22)}$ = 4.30	.1664	**9.520**	**$F_{(1,19)}$ =4.54**	.4075
Mixed Biface-Core (25:75)	-.6534	.3878	$F_{(1,22)}$ = 4.30	.0702	**11.8161**	**$F_{(1,19)}$ =4.54**	.5037
Mixed Biface-Small Core (75:25)	-.9880	**13.0180**	**$F_{(1,20)}$ =4.35**	.4048	1.6191	$F_{(1,17)}$ =4.45	.1691
Mixed Biface-Small Core (50:50)	-.7804	3.0205	$F_{(1,20)}$ = 4.35	.1972	**7.813**	**$F_{(1,17)}$ =4.45**	.3767

[a] Critical values of F at an alpha level of .05.

[b] Absolute difference between slopes of control and test assemblages.

was classified as significantly different from the experimental core-reduction assemblage, while the simulated assemblage consisting of a similar mix of debitage resulting from biface reduction and both large- and small-core reduction was determined to be significantly different from the experimental biface-reduction assemblage. Reexamination of the linearized distributions for these two assemblages (Figures 32a and 33a) did not reveal any patterns which might explain this discrepancy. In fact, the right sides of the flake-size distributions for both assemblages appear to contradict the ANOVA results: the simulated biface and small-core assemblage appears more similar to the experimental core-reduction assemblage than the biface-reduction assemblage, while the simulated biface and core-reduction flake assemblage appears more similar to the experimental biface-reduction assemblage.

These results illustrate both the potential and limitations of using statistical methods to characterize waste-flake assemblages. While the statistical comparison of slopes provides a certain amount of objective rigor to the analysis of flake-size distributions, it cannot be used uncritically. Successful use of ANOVA, or any other statistical characterization procedure, is best accomplished in combination with visual comparison of the linearized distributions.

Conclusion

The results of the experimental program indicate that the Sullivan-Rozen typology and the analysis of flake-size distributions provide powerful tools for characterizing archaeological debitage assemblages in terms of the reduction strategies that were primarily responsible for their formation. The two methods were used in this study to determine the extent to which patterned-tool reduction or core-reduction technologies were practiced at sites in the study area. The results of these applications are presented in Chapter 11.

Use of these techniques is not without its problems, as illustrated by the application of these methods to simulated assemblages containing various mixes of debitage resulting from patterned-tool-

and core-reduction activities. However, when used in combination with graphic representations of cumulative distribution curves (for the Sullivan-Rozen flake categories) and linearized distribution curves (for flake-size data), it is possible to identify those archaeological assemblages that may be the product of a combination of reduction activities. These interpretations can then be tested using independent data. The techniques can be refined through additional research that focuses on the problem of characterizing mixed assemblages.

CHAPTER 9
STRATEGIES FOR COPING WITH PROCUREMENT RISK

In this chapter I discuss various risk-abatement strategies practiced by the prehistoric inhabitants of the study area with regard to the procurement of lithic raw materials: direct and indirect acquisition, raw-material diversification, scavenging, reuse, and recycling, and storage. The data indicate variability in all of these activities at both the spatial and temporal scales of analysis.

In this and the following chapters, I make reference to various artifact classes from each of the sites included in the study. A breakdown of assemblage composition by raw-material type for each excavated and tested component used in this study is presented in Appendices A-D. Metric data for hafted-bifaces from excavated and surface-collected sites are presented in Appendix E.

Raw-Material Acquisition

In this section differential strategies of raw-material acquisition among Archaic and post-Archaic hunter-gatherers are discussed. The data are meant to describe the spatial and temporal distributions of various raw-material types. Modes of acquisition are inferred on the basis of informative trends in the data and on comparison with the expectations outlined in Chapter 6.

Distance-Decay Patterns

The small sample sizes and the patchy spatial distribution of sites in this study's data set make the application of sophisticated distance-decay models (e.g., Findlow and Bolognese 1982; Hodder and Orton 1976; Renfrew 1977) difficult. Consequently, I have chosen simply to plot the proportional abundance of the various raw materials that occur in each Archaic and post-Archaic assemblage against distance to the nearest known source location for each raw-material type (in this case, quarry clusters) without sophisticated transformations or statistical comparisons with formal distance-decay models. In an effort to identify trends in the data, I have attempted to find the best-fit regression line for each raw material. I then use these regression lines in a qualitative way to arrive at preliminary interpretations regarding procurement strategies. Where available, comparative data from sites in chert-rich regions have been included to increase the representativeness of the distance-decay relationships. With one exception (the Wells site in Pasco County), the data from these sites have been obtained from published reports. The raw data for all sites are presented in Table 26.

The fall-off patterns for the various raw-material types indicate some interesting similarities and differences between Archaic and post-Archaic assemblages. In Figure 35, silicified coral is plotted for all Archaic and post-Archaic assemblages in the data set plus 16 additional assemblages (9 Archaic, 7 post-Archaic) from sites located in or near the Hillsborough, Withlacoochee, and Peace River quarry clusters. Silicified coral is discussed first because it is relatively easy to identify and data on its relative abundance are plentiful the literature. Consequently, the resulting fall-off curves are perhaps the most representative of a typical distance-decay relationship of any of the raw materials discussed below.

As shown in Figure 35, both the Archaic and post-Archaic assemblages exhibit hyperbolic fall-off curves indicating a relatively rapid decrease in abundance followed by a leveling-off as distance to source locations increases. This leveling off appears to happen more rapidly with the Archaic assemblages, in other words, within 10-20 km of a source versus 20-30 km for post-Archaic assemblages. The strength of the hyperbolic relationship also is stronger for Archaic assemblages (r=.672, r^2 = .452, p = 002) than for the post-Archaic (r = .389, r^2 = .151, p = .134). An examination of Figure 35b indicates that two post-Archaic assemblages with high abundance values (8HI471 and 8HG27) may be unduly influencing this curve; however, examination of the standardized residual values (i.e., the actual value of Y minus the predicted regression value) for the Archaic and post-

Table 26. Data on distance in kilometers to nearest source location (D) and abundance of raw-material types (quarry clusters) in Archaic and post-Archaic assemblages. Except where noted, abundance is calculated as a percent of all lithics (tools, cores, and debitage) present in an assemblage.

Sites	Peace River QC		Hillsborough River QC		Withlacoochee QC		Ocala & LS/LP QCs		Silicified Coral		References
	D	Pct.	D	Pct.	D	Pct.	D[a]	Pct.[a]	D	Pct.	
Archaic Assemblages											
8HG18	64.4	.00	103.0	57.5	112.7	11.46	(O)141.6	10.00	112.7	12.50	This study
8HG20	64.4	.00	125.5	72.41	112.7	3.45	141.6	.00	112.7	13.79	This study
8HG34	64.4	.00	125.5	89.29	112.7	.00	141.6	.00	112.7	10.71	This study
8HG35	42.6	5.36	82.1	23.21	94.9	42.86	(O)115.9	1.79	82.1	14.29	This study
8HG51	51.5	67.85	96.6	10.66	117.5	4.91	(O)156.1 (L)152.9	.51 .17	117.5	10.49	This study
8HG678	55.5	14.29	93.3	44.64	125.5	3.57	(O)159.3	8.93	93.3	14.29	This study
8HG767	47.5	29.78	86.1	27.66	101.4	10.64	138.4	.00	86.1	4.25	Janus Research 1996a; This study
8HI450D									.8	51.24[b]	Daniel and Wisenbaker 1981:Table 12
8HI452									5.6	33.39[b]	Estabrook and Newman 1984:181-282
8HI483B									2.4	49.58[b]	Gagel 1981:Table 28
8HI557									5.6	4.86[b]	Austin and Ste. Claire 1982:Table 7

Table 26 (Continued).

Sites	Peace River QC		Hillsborough River QC		Withlacoochee QC		Ocala & LS/LP QCs		Silicified Coral		References
	D	Pct.	D	Pct.	D	Pct.	D[a]	Pct.[a]	D	Pct.	
8HI559									5.6	5.40[b]	Austin and Ste. Claire 1982:61
8HI3281	58.7	.00	.4	97.04	23.3	.47	62.8	.00	3.2	2.50	Williams and Estabrook 1987:25-107
8HI5429	57.1	.00	1.6	98.65	24.1	.00	90.1	.00	4.8	1.35	Janus Research 1996b:38-43
8HR68	27.4	4.33	29.8	74.01	61.2	1.08	106.2	.00	29.8	8.30	Janus Research 1995b:Table 8, This study
8HR71	24.9	1.90	35.4	54.37	66.0	22.43	(O)109.4	.76	35.4	10.27	Janus Research 1995b:Table 16; This study
8HR92	18.5	4.90	38.6	57.25	67.6	11.96	(O)104.6 (L)115.1	1.18 .20	38.6	14.12	Janus Research 1995b:Table 24; This study
8OS123	58.7	24[c]	74.8	.95	39.4	86.67	57.1[d]	1.19	74.8	7.62	Estabrook 1991:57-73
Wells Site	51.5	.00	16.1	50.86	4.0	15.24	45.1	.00	16.1	28.38	This study
Post-Archaic Assemblages											
8GL13	88.5	4.26	151.3	27.69	167.4	3.81	(O)201.2 (L)209.2	1.57 1.35	151.3	6.84	This study
8HG18	64.4	3.13	103	60.42	112.7	11.46	(O)141.6	1.04	103.0	10.42	This study

Table 26 (Continued)

Sites	Peace River QC		Hillsborough River QC		Withlacoochee QC		Ocala & LS/LP QCs		Silicified Coral		References
	D	Pct.	D	Pct.	D	Pct.	D[a]	Pct.[a]	D	Pct.	
8HG20	64.4	.84	125.5	66.39	112.7	10.08	(O)141.6	1.68	112.7	9.24	This study
8HG27	64.4	.00	125.5	35.44	112.7	7.59	(O)141.6	3.80	112.7	31.65	This study
8HG675	54.7	40.00	99.8	40.00	122.3	.00	156.1	.00	99.8	10.00	This study
8HG678	55.5	31.52	93.33	44.57	125.5	3.26	(O)159.3	2.17	93.3	7.61	This study
8HI471									10.5	57.87[b]	Austin 1982:Table 9
8HI515	53.9	.00	6.4	97.67	22.5	.01	67.6[d]	.01	23.3	.49	Archaeological Consultants, Inc./ Janus Research 1994 5-3-5-16
8HI558									5.6	17.28[b]	Estabrook and Newman 1984:125
8HI981	82.1	.00	4.0	86.84	42.6	.00	77.2	.00	20.9	12.18	Estabrook and Williams 1992:43-48
8HR44	14.5	89.94	41.0	6.15	65.2	.56	103.0	.00	103.0	.00	This study
8HR48	13.7	40.70	40.2	29.65	66.8	1.01	(O)106.2 (L)111.0	2.01 4.52	40.2	12.56	This study
8LL33, 36, 37	99.8	.00	142.4	60.31	172.2	5.34	(L)215.6	3.82	138.4	7.63	Austin 1995a; This study

Table 26 (Continued).

Sites	Peace River QC		Hillsborough River QC		Withlacoochee QC		Ocala & LS/LP QCs		Silicified Coral		References
	D	Pct.	D	Pct.	D	Pct.	D[a]	Pct.[a]	D	Pct.	
8PI1753	86.9	.00	11.3	51.68	59.5	1.68	103.0	00	19.3	6.49	Austin 1995b:Table 10.19; This study
8PO4777	4 8	29.41	40.2	38.82	62.0	7.06	(L)105 4	1.18	40.2	16.47	Janus Research 1996c:46-48
8PO4778	5.2	21 88	40.6	45.31	62 4	10.94	105.8	.00	40.6	4.69	Janus Research 1996c:53-54

[a] If artifacts are present, individual quarry clusters are indicated in parentheses: O = Ocala Quarry Cluster; L = Lower Suwannee/Lake Panasoffkee Quarry Cluster. If no artifacts are present, the distance indicated is to the nearest quarry cluster containing Ocala Limestone chert.

[b] Debitage only

[c] A hafted biface and a small, but unspecified number of opaline flakes identified by Estabrook (1991.58, 64) as coming from the Upper Withlacoochee Quarry Cluster are now believed to be from the Peace River Quarry Cluster (Richard Estabrook, personal communication, 1996).

[d] No distinction is made between quarry clusters containing Ocala Limestone cherts. Distance is to the nearest known source of Ocala Limestone chert

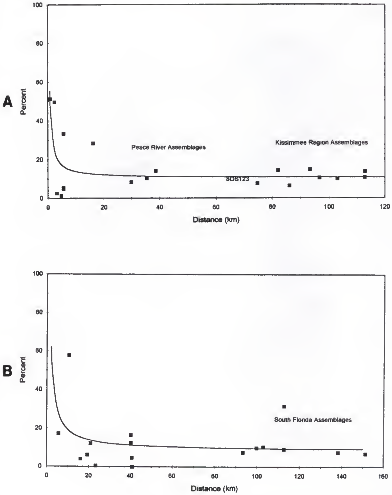


Figure 35. Distance-decay relationships for silicified coral: a) Archaic assemblages; b) post-Archaic assemblages. Both data sets exhibit hyperbolic fall-off patterns.

Archaic data sets did not reveal any significant differences between them. Both data sets have relatively equal numbers of assemblages with residual values that are higher and lower than the predicted regression values (Figure 36).

Figure 37 shows the fall-off patterns for Hillsborough River Quarry Cluster cherts. While the Archaic data do produce a general fall-off in abundance with distance (Figure 37a), there is a wide scatter of data points with a strong linear trend beyond 70 km. This suggests that regional patterning may be present. This patterning is made more apparent when the data are separated and plotted by region (Figure 37b). In the Peace River valley, a linear pattern is present indicating a decrease in the use of these cherts as distance to source locations becomes greater, while in the Kissimmee region there is a dramatic increase in the dependence on Hillsborough River cherts as distance to source areas increases. The correlations for these patterns are very high. $r = -.972$, $r^2 = .945$, $p = .005$ for the Peace River region; $r = .871$, $r^2 = .759$, $p = .011$ for the Kissimmee region assemblages. A third regional pattern is suggested by the assemblage data from 8OS123 and the Wells site, both located to the northeast of the study area. Since there are only two data points, it is not possible to make a conclusive statement, but the pattern does indicate a linear fall-off in the use of Hillsborough River cherts as they are replaced in Archaic assemblages by local, Withlacoochee Quarry Cluster cherts.

Regional differences are not as dramatic for the post-Archaic assemblages, and it is possible to fit a regression curve to the composite data (Figure 37c); however, the best fit is provided by treating the two regions separately. When this is done, logarithmic patterns are evident for both the Peace River valley and for assemblages in south Florida, which include sites in the Kissimmee River valley and the Lake Wales Ridge region as well as Fort Center and Pineland (Figure 37d). The scatters of data points around both regression lines are greater than are exhibited by the Archaic assemblages, as indicated by comparing the plots of residual values (Figure 38) Nonetheless, the relationships appear to be quite strong: $r = -.883$, $r^2 = .780$, $p = .009$ for the Peace River assemblages, $r = -.825$, $r^2 = .681$, $p = .006$

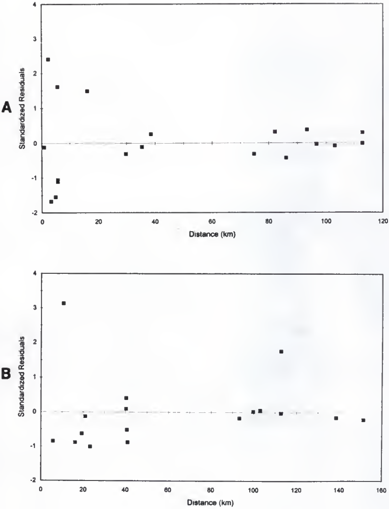


Figure 36. Plots of standardized residual values versus distance for silicified coral. a) Archaic assemblages; b) post-Archaic assemblages.

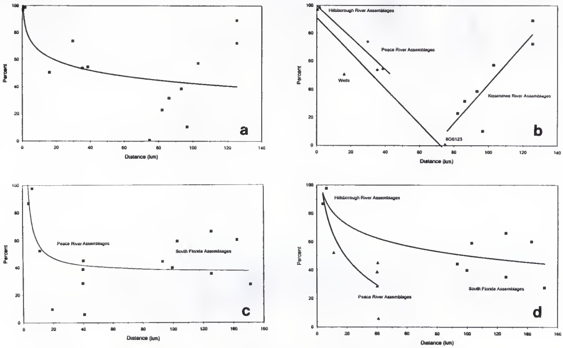


Figure 37. Distance-decay relationships for Hillsborough River Quarry Cluster cherts: a) Archaic assemblages, b) Archaic assemblages separated by region; c) post-Archaic assemblages; d) post-Archaic assemblages separated by region.

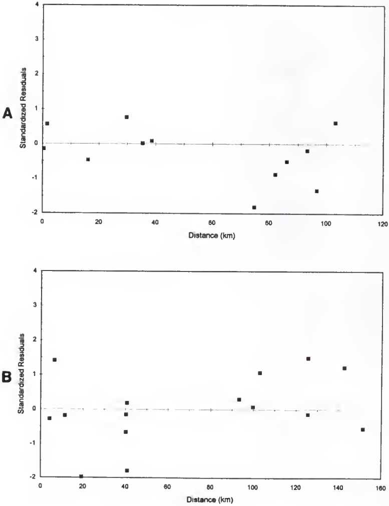


Figure 38. Plots of standardized residual values versus distance for Hillsborough River Quarry Cluster cherts: a) Archaic assemblages; b) post-Archaic assemblages.

for the south Florida assemblages. The assemblage from 8PI894B was removed from this second plot (Figure 37d) because it is located to the northwest of the Hillsborough River Quarry Cluster and so reflects a different directional trend, as is indicated by the high incidence of cherts from the nearby Caladesi Quarry Cluster (Austin and Estabrook 1991:43).

Among Archaic assemblages, cherts from the Withlacoochee River Quarry Cluster exhibit a weak linear trend of decreasing abundance with distance (Figure 39a; $r = -.208$, $r^2 = .043$, $p = .519$). This pattern is due to the presence of one site (8OS123) with a high abundance value for this chert. This site is interesting because it is located nearly 40 km from the nearest known source location for Withlacoochee cherts. However, the Withlacoochee Quarry Cluster represented the nearest source of lithic raw materials for the site's occupants, and so these cherts are well represented in this assemblage. The Wells site, on the other hand, is located near the interface of the Hillsborough and Withlacoochee quarry clusters, and consequently the proportion of cherts from the latter quarry cluster are lower than at 8OS123 (Table 26). The high proportion of Withlacoochee cherts at 8OS123 reflects a larger regional trend of increasing dependence on Withlacoochee Quarry Cluster cherts with distance that is analogous to the pattern exhibited by Hillsborough River Quarry Cluster cherts in the Kissimmee region (cf. Estabrook 1992). In both cases, the closest, high-quality chert dominates assemblages at sites in peripheral chert-poor areas.

By removing the 8OS123 data, as well as the data from other sites located to the north of the Peace River and Kissimmee regions, it is possible to examine more local trends among south Florida assemblages. The data from the Wells site has been retained as representative of an Archaic assemblage within the Withlacoochee Quarry Cluster. The resulting plot is shown in Figure 39b. The linear trend of decreasing abundance with distance remains, although the relationship is not a strong one ($r = -.234$, $r^2 = .055$, $p = .505$).

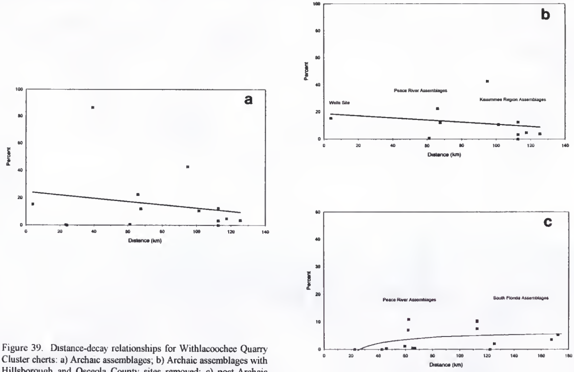


Figure 39. Distance-decay relationships for Withlacoochee Quarry Cluster cherts: a) Archaic assemblages; b) Archaic assemblages with Hillsborough and Osceola County sites removed; c) post-Archaic assemblages.

There are no data available for post-Archaic sites located near the Withlacoochee Quarry Cluster, which results in an artificial distance-decay curve with no assemblages having a high abundance of this chert type (Figure 39c). The hyperbolic curve that has been fit to the data that are available indicates a weak tendency for this chert type to increase with distance in south Florida (r = -.412, r^2 = .169, p = .125). However, if assemblages from sites located closer to the source areas for these cherts had been included, it is likely that a different curve would have resulted.

Peace River cherts are plotted in Figures 40 and 41. Among Archaic assemblages, Peace River Quarry Cluster cherts appear to display a weak, hyperbolic, positive trend with a few outlying assemblages with high abundance values (Figure 40a; r = -.073, r^2 = .005, p = .800). When the spatial distribution of the sites with high abundance values is examined (8HG35, 8HG51, 8HG678, 8HG767, 8HR68, 8HR71, and 8HR92), all are located in or to the south of the source area for this chert. Only one Archaic assemblage from a site located to the north of this quarry cluster contains Peace River chert. This is 8OS123, where a single hafted biface and a few waste flakes were recovered (Estabrook 1991:58, 64, personal communication 1996).

These data indicate a strong directional trend in the distribution of this raw material. When assemblages from sites located to the north of the Peace River Quarry Cluster are removed and the data are replotted, a hyperbolic increase in abundance for this chert type is indicated as distance increases to the south (Figure 40b). The strength of this relationship remains weak, however, because of the presence of three sites (8HG18, 8HG20, and 8HG34) with no Peace River chert present (r = -.199, r^2 = .040, p = .586). The relationship is strengthened substantially by removing these three sites (r = .781, r^2 = .610, p = .281), resulting in an exponential curve (Figure 40c). The fact that this raw material exhibits a patchy distribution among sites in south Florida suggests that it was not considered a high-utility resource despite its close proximity relative to other quarry clusters.

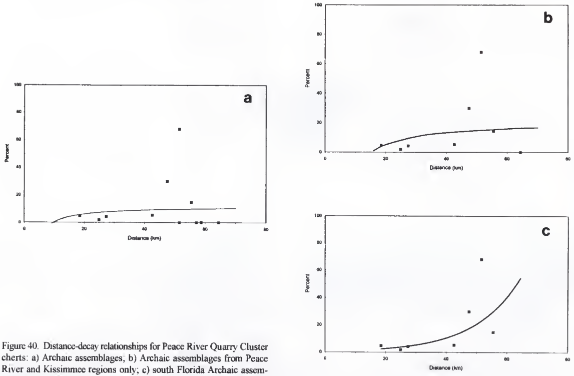


Figure 40. Distance-decay relationships for Peace River Quarry Cluster cherts: a) Archaic assemblages; b) Archaic assemblages from Peace River and Kissimmee regions only; c) south Florida Archaic assemblages, sites with zero representation of Peace River chert removed.

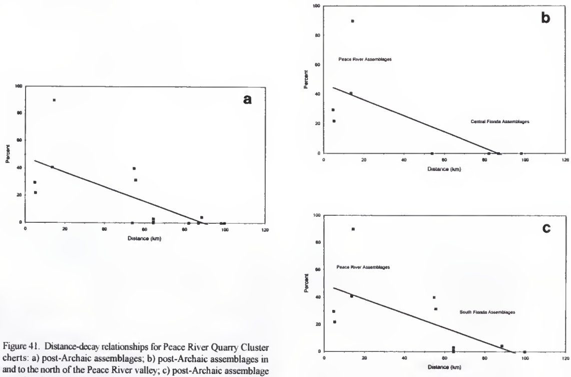


Figure 41. Distance-decay relationships for Peace River Quarry Cluster cherts: a) post-Archaic assemblages; b) post-Archaic assemblages in and to the north of the Peace River valley; c) post-Archaic assemblage in and to the south of the Peace River valley.

The pattern is exactly the opposite for post-Archaic assemblages (Figure 41a), which exhibit a decrease in the use of this chert type to the north and south ($r = -.689$, $r^2 = .475$, $p = .005$). Like the Archaic assemblages, none of the post-Archaic assemblages from sites located to the north of this quarry cluster contain any Peace River material, which results in a fairly rapid fall-off (Figure 41b; $r = -.688$, $r^2 = .473$, $p = .058$). Unlike the Archaic sites, post-Archaic assemblages in the Peace River Valley possess the greatest amounts of this chert type followed closely by the two sites (8HG675 and 8HG678) located on the Lake Wales Ridge; the Kissimmee River sites and Fort Center have the lowest representation of Peace River chert (Table 26). The fall-off pattern to the south is only slightly less rapid than to the north, but it remains linear in form (Figure 41c; $r = -.646$, $r^2 = .417$, $p = .031$).

The final raw material that is examined consists of Ocala Limestone cherts from both the Ocala and Lower Suwannee/Lake Panasoffkee quarry clusters. While the proportional abundance of these cherts is small in both Archaic and post-Archaic assemblages, cherts derived from the Ocala Limestone occur regularly in assemblages throughout south Florida, particularly in the form of hafted bifaces (see Appendix A). In Figure 42, both the Archaic and post-Archaic assemblages indicate very slight increases in the abundance of these raw materials with distance to source areas. The Archaic pattern is linear in form ($r = .366$, $r^2 = .134$, $p = .161$) while the post-Archaic pattern is hyperbolic ($r = -.372$, $r^2 = .138$, $p = .114$). Although caution is required in interpreting these distance-decay relationships because no data are available for assemblages from sites located close to source locations for these cherts, the spatial distribution of the sites that contain these materials is revealing. In almost every case, they are located to the south of the Hillsborough River Quarry Cluster at distances in excess of 100 km from the nearest source location. This is true for both Archaic and post-Archaic sites. The absence of sites containing these chert types in the Hillsborough River Quarry Cluster is probably due to the local presence of abundant, high-quality chert.

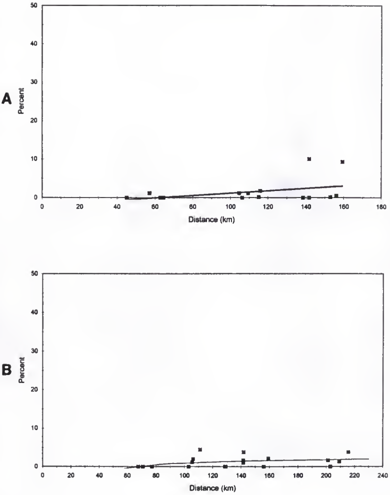


Figure 42. Distance-decay relationships for Ocala and Lower Suwannee/Lake Panasoffkee Quarry Cluster cherts: a) Archaic assemblages; b) post-Archaic assemblages.

Table 27. Summary of distance-decay patterns for lithic raw materials by cultural period.

Raw Materials	Archaic Assemblages		Post-Archaic Assemblages	
	Best-fit Regression	Fall-off Trend	Best-fit Regression	Fall-off Trend
Silicified Coral	Hyperbolic	Negative	Hyperbolic	Negative
Hillsborough River QC	Linear	Positive (Kissimmee region) Negative (Peace River region)	Logarithmic	Negative
Withlacoochee QC	Linear	Negative	Hyperbolic	Weakly positive
Peace River QC	Hyperbolic	Positive	Linear	Negative
Ocala & Lower Suwannee/Lake Panasoffkee QCs	Linear	Weakly positive	Hyperbolic	Weakly positive

Distance-decay plots for the two remaining quarry clusters (Caladesi and Brooksville) were not attempted because of the small amounts of these materials at sites included in this study.

Summary. Table 27 summarizes the distance-decay patterns for the various raw-material types present in the study collection. A number of different regression curves (linear, hyperbolic, and logarithmic) characterize the spatial distributions of raw materials in post-Archaic assemblages suggesting that several different types of procurement strategies were active during this time. On the other hand, the Archaic fall-off patterns are characterized best by linear relationships, with two raw materials exhibiting hyperbolic patterns This suggests more limited types of procurement.

As indicated in Chapter 6, a linear fall-off pattern is often interpreted as reflecting direct acquisition while various types of curvilinear patterns are interpreted as indicating different kinds of indirect procurement. However, Findlow and Bolognese (1982:74) indicate that hyperbolic curves reflect acquisition patterns that are intermediate between direct acquisition and down-the-line exchange Except for silicified coral, the fall-off trends for the Archaic and post-Archaic hyperbolic patterns are positive rather than negative, indicating an increase in abundance of these raw materials with distance. The hyperbolic increase of Peace River cherts in Archaic assemblages located to the south of this source area is difficult to interpret within the context of the model presented by Findlow and Bolognese (1982; see Table 4) because it has been assumed that Archaic groups practiced a mobile settlement strategy. If this assumption is correct, then a direct acquisition strategy would be expected and the resulting fall-off pattern should be linear in form. The hyperbolic pattern may be the result of having too few data points or it may reflect some type of down-the-line exchange or gift exchange in combination with direct access, as suggested by Findlow and Bolognese.

The weakly positive trends for Withlacoochee and Ocala Limestone cherts are probably the result of having no data for post-Archaic sites located near the source areas for these materials. On the other hand, if these data had been available, they might have masked the subtler trends which are exhibited by the south Florida assemblages. These positive, curvilinear patterns could reflect some form of directed exchange where lithic materials arrive at a location after little or no reduction by intermediate users. This would imply that the materials were not meant for utilitarian use and may have been transported as finished, unused implements.

With regard to the specific distance-decay patterns exhibited by the various raw materials, perhaps the most significant is the increase in abundance of Hillsborough River Quarry Cluster cherts, and to a lesser extent the Peace River Quarry Cluster cherts, with distance in the Archaic assemblages. The high abundance values for these raw materials are only partly the result of using a closed number system to represent abundance since post-Archaic assemblages do not exhibit a similar increase in these or any other raw materials for which there are sufficient data. This suggests that there are strong directional trends in the distribution of these raw materials during the Archaic period. These trends may be related to lithic provisioning by residentially mobile groups traveling through areas containing these chert types prior to moving on to chert-poor areas.

The post-Archaic fall-off pattern for Peace River cherts is linear in form, reflecting direct procurement of this chert at source locations by groups in close proximity to these outcrops. The gradual negative fall-off of this material to the south, along with its patchy occurrence among south Florida sites, suggests that the distribution of this material far to the south of its source may have occurred via some form of down-the-line exchange since there is no sharp demarcation between supply zone and fall-off zone.

Flake-to-Core Ratios

By examining the ratios of waste flakes to transportable items of lithic raw material, it is possible to infer the sizes of the materials that entered a region or site. As discussed in Chapter 6, a low flake-to-core ratio would be expected with prestige or gift exchange, since the items most likely to be exchanged would be finished or nearly finished implements. Moreover, down-the-line exchange and some forms of utilitarian exchange often result in a reduction of tool or core size as "middlemen" use the materials before passing them on. A direct procurement strategy should be characterized by greater variation in flake-to-core ratios since it would be necessary to transport enough usable raw material to guard against a resource shortfall in areas where lithic outcrops are scarce or nonexistent.

Transportable items may consist of bifaces (either preforms or finished implements) or cores (i.e., conventional cores and hammerstones). For convenience, I refer to both of these artifact classes as "cores," although it should be noted that conventional cores and hammerstones make up a very low percentage of the transportable items in the study collection (see Appendices A and B). Although other tool forms (e.g., flake tools, microliths, unifaces) are transportable, they do not represent significant sources of raw material for manufacturing additional tools. Therefore, I have not included them as transportable items. Flake tools have, however, been included in the flake totals since they may have been produced on-site through biface or core reduction

Table 28 Flake-to-core (F:C) ratios by raw-material categories for Archaic and post-Archaic assemblages in the Peace River region.

Raw Materials	Cores[a]	Flakes[b]	F:C Ratio
Archaic Assemblages			
Peace River QC	1	41	41.00
Hillsborough River QC	13	624	48.00
Withlacoochee QC	1	122	122.00
Ocala QC	0	8	.00[c]
Lower Suwannee/ Lake Pannasofkee QC	1	0	.00
Silicified Coral	5	117	23.40
Post-Archaic Assemblages			
Peace River QC	11	231	21.00
Hillsborough River QC	6	64	10.66
Withlacoochee QC	1	2	2.00
Ocala QC	1	3	3.00
Lower Suwannee/ Lake Pannasofkee QC	1	8	8.00
Silicified Coral	1	24	24.00

[a] Totals include bifaces, conventional cores, and hammerstones.
[b] Totals include utilized and modified flakes.
[c] Value of .00 is used because division by zero is not possible.

Tables 28 and 29 provide flake-to-core (F:C) ratios for composite Archaic and post-Archaic assemblages in the Peace River and Kissimmee regions, respectively. Assemblages from sites in the Kissimmee River basin and Lake Wales Ridge areas together comprise the Kissimmee region while assemblages from sites in the Peace River valley comprise the Peace River region. The data were partitioned in such a way because it was suspected that the availability of chert in the Peace River Quarry Cluster might result in higher ratios for this chert type in assemblages from the Peace River

Table 29. Flake-to-core (F:C) ratios by raw-material categories for Archaic and post-Archaic assemblages in the Kissimmee region.

Raw Materials	Cores[a]	Flakes[b]	F:C Ratio
Archaic Assemblages			
Peace River QC	4	422	105.50
Hillsborough River QC	4	179	44.75
Brooksville QC	2	14	7.00
Withlacoochee QC	3	63	21.00
Ocala QC	2	11	5.50
Silicified Coral	4	87	21.75
Post-Archaic Assemblages			
Peace River QC	7	35	5.00
Hillsborough River QC	14	212	15.14
Withlacoochee QC	1	36	36.00
Ocala QC	2	6	3.00
Silicified Coral	6	54	9.00

[a] Totals include bifaces, conventional cores, and hammerstones.
[b] Totals include utilized and modified flakes.

region. For comparison, flake-to-core ratios also were calculated for 10 sites located in the Hillsborough River region (6 Archaic and 4 post-Archaic), all of which are in fairly close proximity to lithic source locations (Table 30).

As expected, the F:C ratios of Archaic and post-Archaic assemblages in both the Peace River and Kissimmee regions are generally lower than those in the Hillsborough River region. However, the data in Tables 28 and 29 do indicate that lithic raw materials were treated differently by Archaic and post-Archaic peoples in both of these regions, with the Archaic assemblages exhibiting a wider range of variability in F:C ratios than the post-Archaic assemblages. For example, Ocala, Lower Suwannee/Lake Panasoffkee, and Brooksville quarry cluster cherts all exhibit very low F:C ratios in the two

Table 30. Flake-to-core (F C) ratios by raw-material categories for Archaic and post-Archaic assemblages in the Hillsborough River region.

Sites	Cores[a]	Flakes	F C Ratio	Reference
Archaic Assemblages				
8HI452	150	23,586	196.55	Estabrook and Newman 1984:Tables 54-56
8HI473	451	113,117	250.81	Chance 1982; Chance and Misner 1984
8HI476A	138	33,153	240.24	Chance 1983b
8HI557	56	7123	127.20	Austin and Ste. Claire 1982:82
8HI559	3	623	207.66	Austin and Ste. Claire 1982:58
8HI5446	96	15,808	164.67	Meadows 1995
Wells	6	509	84.83	This study
Post-Archaic Assemblages				
8HI471	26	1761	67.73	Austin 1982:113
8HI515	25	7295	291.80	Archaeological Consultants, Inc./Janus Research 1984
8HI556	48	10,594	220.71	Austin and Ste. Claire 1982:146, Tables 21-22
8HI558	35	6672	190.63	Estabrook and Newman 1984:114

[a] Totals include bifaces, conventional cores, core tools, and hammerstones.

composite Archaic assemblages. Since only one of the transportable items made from these cherts is a conventional core (Appendix A), it can be inferred that: 1) these materials were imported primarily as bifacial implements, 2) the bifaces were likely finished implements, and 3) intensive reduction of these raw materials did not occur and was probably limited to tool maintenance. On the other hand, chert from the Withlacoochee Quarry Cluster exhibits a high F C ratio in the Peace River Archaic assemblage, which suggests that these cherts were imported in relatively unfinished forms and were meant to be worked on site. The fact that only one transportable implement, a hafted biface, is present in this composite assemblage suggests that the implements that resulted from the reduction of this material were removed for use and discard at different locations A high F:C ratio also is indicated for Peace River Quarry Cluster chert in the Kissimmee region Archaic assemblage while the ratio for Withlacoochee Quarry Cluster cherts in this assemblage is relatively low The ratio for Peace River cherts is influenced greatly by the lithic assemblage from the Driggers site (8HG51), where Peace River cherts have a very high F:C ratio (397:4 or 99.25).

All other raw materials in the two composite Archaic assemblages exhibit F:C ratios that are intermediate between these two extremes. They also are considerably lower than those exhibited by assemblages from the Hillsborough River region (Table 30).

In comparison, the post-Archaic assemblages from the Peace River and Kissimmee regions exhibit moderately low to low F:C ratios for all raw materials for which there is sufficient numbers of artifacts to provide meaningful data. This suggests that all of these materials entered these sites in small packages, i.e., late-stage preforms, finished implements, or small cores, and that the reduction of these materials was not intensive. The bifaces found at these post-Archaic sites are typically broken fragments of finished tools such as stems, bases, tips, or midsections, which reinforces the notion that much of the debitage at these sites is the result of tool maintenance rather than tool production.

The Pineland and Fort Center assemblages have the lowest F:C ratios of all the assemblages in the study collection (Table 31). Virtually all of the raw materials represented at these two sites have ratios of less than 5 The only exception is the cobble chert at Fort Center with a F:C ratio of 9.59. Tested cobbles and unmodified cobbles were not included in the core category for this material since their unmodified conditions indicated that they did not contribute to the flake assemblage. However, if these transportable items are included in the "core" category, then the F:C ratio drops to 3.09. Only three bifaces were made from this material and flake tools and microliths appear to have been the intended tool forms (Appendix B).

Table 31. Flake-to-core (F:C) ratios by raw-material categories for lithic assemblages from Pineland (8LL33, 36, 37), Fort Center (8GL13), and Yat Kitischee (8PI1753).

Raw Materials	Cores[a]	Flakes[b]	F:C Ratio
8LL33, 36, 37			
Hillsborough River QC	15	58	3.87
Caladesi QC	0	1	.00[c]
Withlacoochee QC	2	5	2.50
Lower Suwannee/ Lake Pannasofkee QC	5	0	.00
Silicified Coral	4	6	1.50
8GL13			
Peace River QC	7	31	4.43
Hillsborough River QC	49	194	3.96
Caladesi QC	1	2	2.00
Withlacoochee QC	14	20	1.43
Ocala QC	5	9	1.80
Lower Suwannee/ Lake Pannasofkee QC	7	5	.71
Cobble Chert	29[d]	278	9.59
Silicified Coral	23	38	1.65
8PI1753			
Hillsborough River QC	15	199	13.27
Turtlecrawl Point QC	8[e]	92	11.50
Caladesi QC	3	15	5.00
Withlacoochee QC	2	5	2.50
Silicified Coral	7	20	2.86

[a] Totals include bifaces, conventional cores, bipolar cores, and hammerstones.

[b] Totals include utilized and modified flakes.

[c] Value of .00 used because division by zero is not possible.

[d] Tested cobbles and unmodified cobbles not included in this total.

[e] Unmodified chert "rods" not included in this total.

Bifaces are the primary transportable item represented in the Withlacoochee, Ocala, Lower Suwannee/Lake Panasoffkee, and silicified coral raw-material assemblages. The very low F:C ratios for these materials, the large number of bifaces made from these materials, and the comparatively low number of cores (Appendix B), indicate that these materials entered these sites primarily as bifacial implements in near-finished condition and that on-site reduction was minimal. The very low F:C ratios for these materials also indicate extremely high rates of tool discard. High rates of discard also are evident at Yat Kitischee, despite the fact that it is located near abundant lithic resources (Table 31). This rate would be even higher for Turtlecrawl Point cherts if the 33 unmodified chert "rods" had been included in the "core" total.

Summary. The variable flake-to-core ratios for Archaic assemblages is consistent with the strategy of direct procurement that was suggested by the distance-decay analysis. If, as argued by Kelly (1988) and Morrow (1996), the optimal solution to the problem of lithic provisioning in a chert-poor area is to transport large bifaces that can be used as preforms for reduction into functional hafted bifaces or as cores for the production of flake tools, then one archaeological manifestation of such a strategy would be variability in both the sizes of discarded bifaces and the amount of lithic debitage produced at different sites as preforms are worked into functional implements, flakes are struck for expedient use, and hafted bifaces are rejuvenated and resharpened.

Flake-to-core ratios for the post-Archaic assemblages are uniformly low. Furthermore, they tend to be low regardless of geographic location, although those sites located farthest from a chert source (i.e., Fort Center and Pineland) tend to have the lowest ratios of all. This is consistent with a strategy of indirect procurement where acquisition costs associated with such a transaction can be offset by acquiring lithic materials in finished or nearly finished forms. These low ratios also imply high discard rates for bifaces and cores, and this is consistent with the functional interpretation of these post-Archaic sites as permanent habitations where tool maintenance and discard would have been more likely to have occurred (cf. Binford 1977; Torrence 1989b). The fact that F:C ratios at Yat Kitischee are substantially lower than those at post-Archaic sites in the Hillsborough River basin may reflect the former's access to a secondary raw-material source, i.e., shell, which reduced the overall demand for stone at this site

Evidence for Prestige Exchange

At Fort Center, the presence of large middens, a ceremonial center, cemetery, and post-molds for structures are highly suggestive of permanent habitation. Moreover, a number of artifacts made from non-local materials such as galena, mica, quartz crystal, granite, diorite, and gneiss were recovered from the site (Steinen 1982:69, 81, 84), and since these materials do not occur in Florida, it can safely be assumed that they were imported via exchange with groups located farther north. Similarly, artifacts made from marine shell and sharks' teeth also were common at the site (Steinen 1982:69-75, 83-87), and these were probably obtained by trade with coastal-dwelling groups. These artifacts provide good supporting evidence that the inhabitants of Fort Center participated in interregional exchange. It is likely that at least some, if not all, of the chert that entered this site also was acquired in this fashion (cf. Steinen 1982:102-110).

Raw materials such as silicified coral and cherts from the Ocala, Lower Suwannee/Lake Panasoffkee, and Withlacoochee quarry clusters exhibit some of the lowest flake-to-core ratios of all sites examined in the study collection. Examination of the data in Appendix B indicates that there is limited evidence for these materials entering the site in the form of cores; the primary transportable items were bifaces. The spatial associations of some of these hafted bifaces with specific intrasite features indicates that they were meant for specialized use within a sacred-ceremonial context.

Mound B and the Charnel Pond A large proportion (31.75 percent) of the 63 hafted bifaces that are complete enough to classify according to Bullen's (1975) typology are Archaic varieties (Culbreath, Hardee, Hillsborough, Levy, Marion, Newnan, and Putnam). Of these, 14 (70 percent) were

Table 32. Cross-tabulation of hafted-biface types by intrasite features at Fort Center (8GL13).

Intrasite Features	Archaic Hafted Bifaces		Other Hafted Bifaces		Totals	
	N	Pct.	N	Pct.	N	Pct.
Mound B & Charnel Pond	14	70.00	14	32.56	28	44.44
Other Proveniences	6	30.00	29	67.44	35	55.56
Totals	20	100.00	43	100.00	63	100.00

X^2 obs = 7.751, $df = 1$, $p = .005$

recovered from Mound B (8) and the associated charnel pond (6). At least one additional Archaic projectile point, a Marion, came from the charnel pond (Steinen 1982:Figure 6.2D, right), but this hafted biface was not available for study and so is not included in these totals. Sears (1982:186-187) considered Mound B to be a ceremonial platform mound, and it contained burials that were apparently interred there after the collapse of the charnel house that was located on a wooden platform above the adjacent pond.

The concentration of Archaic-style projectile points in Mound B and the charnel pond is statistically significant as a chi-square test of independence demonstrates (Table 32). Furthermore, there is a significant concentration of thermally altered bifaces at these two features, and particularly thermally altered silicified coral (Tables 33 and 34). Finally, one silicified coral, Archaic hafted biface recovered from the charnel pond exhibits evidence of unusual edge modification consisting of severe grinding and abrasion. The abrasion is so extensive that flake-scar originations along both lateral margins are obliterated and both edges are rounded to the point that the implement is no longer functional for utilitarian tasks (Figure 43a). Striations are clearly observable and these are oriented parallel to the specimen's edges indicating that the implement was repeatedly abraded in a longitudinal motion. A distinct point of impact is observable at the center of the specimen with fracture planes radiating out from this point. According to Frison and Bradley (1980:44, 97-99), this type of breakage

Table 33. Cross-tabulation of thermally altered bifaces between intrasite features at Fort Center (8GL13).

Intrasite Features	Thermal Alteration								Totals	
	Present		Possible		Thermal Damage[a]		Absent			
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Mound B & Charnel Pond	12	31.58	4	10.53	4	10.53	18[b]	47.37	38[b]	100.01
Other Proveniences	9	10.23	6	6.82	18	20.45	55[b]	62.50	88[b]	100.00
Totals	21	16.67	10	7.94	22	17.46	73[b]	57.94	126[b]	100.01

X^2 obs = 10.267, $df = 3$, $p = .016$

[a] Artifacts with evidence of unintentional exposure to heat (i.e., potlid fractures, crazing, crenated fractures, etc.).
[b] Includes one broken biface that was recovered from two separate proveniences and refitted

Table 34. Cross-tabulation of thermally altered silicified coral bifaces between intrasite features at Fort Center (8GL13).

Intrasite Features	Thermal Alteration						Totals	
	Present		Possible		Absent			
	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Mound B & Charnel Pond	11	100.00	0	.00	0	.00	11	100.00
Other Proveniences	6	50.00	3	25.00	3	25.00	12	100.00
Totals	17	73.91	3	13.04	3	13.04	23	99.99

X^2 obs = 7.441, $df = 2$, $p = .024$

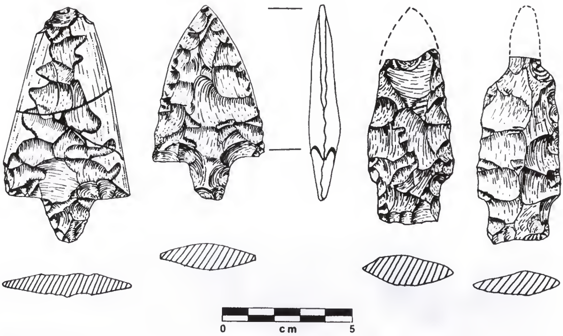


Figure 43. Hafted bifaces from Fort Center's mound-pond complex. a) Marion projectile point with radial fracture and abraded margins recovered from the charnel pond; b) Marion projectile point with heavily abraded edges, provenience unknown; c-d) Columbia projectile points from Mound A

is rarely caused by use, but instead is the result of an intentional blow to the center of the implement that results in a radial fracture. Thus, it appears that this implement was intentionally modified and broken prior to deposition in the charnel pond. A second Archaic hafted biface from Fort Center also exhibits unusual edge modification (Figure 43b), but unfortunately this artifact was surface-collected from an unknown location by the landowners.

These data from Fort Center suggest that well-made, thermally altered bifaces, and particularly Archaic hafted bifaces, were destined for use in ritual or ceremonial contexts at Fort Center. The inclusion of large, well-made bifacial implements in late prehistoric mortuary contexts is well documented in Florida and elsewhere. These bifaces are usually made of exotic, non-local materials, often exhibit grinding and polishing of their margins and interiors, and many have been ritually "killed" through intentional breakage (see Austin 1993:298-300 for a discussion of the occurrence of similar ground and/or broken bifaces in mortuary contexts in Florida).

Mound A. Mound A is an integral component of Fort Center's mound-pond complex and it also contained several large, stemmed, hafted bifaces. Eight of these implements possess straight to slightly expanded stems that are nearly as wide as the blades. In his thesis, Steinen (1971:22) did not assign these bifaces to a specific type, although he later indicated that they resembled Alachua points (Steinen 1982:75). My analysis indicates that seven of the broad-stemmed points from Mound A are Columbia points and one was identified as a possible Columbia (cf. Bullen 1975:19). Two examples of this broad-stemmed type are shown in Figure 43. Four of the Columbia points from Mound A were identified as having been manufactured from Ocala Limestone chert derived from the Lower Suwannee/Lake Panasoffkee Quarry Cluster. Three other Columbia points were identified as possibly coming from this quarry cluster based on similarities in color and chert fabric; however, no identifiable fossils were observable so these three specimens were placed in the "unidentified" raw-material category. The eighth Columbia point was manufactured from chert derived from the Hillsborough River

Quarry Cluster. Another large biface with a broad blade appears to be side-notched or possibly corner-notched with a slightly incurvate base. This specimen was identified as a Broward (cf. Bullen 1975:15) or possible Ocala (cf. Powell 1990:44). This biface was manufactured from Withlacoochee Quarry Cluster chert.

The association of these large hafted bifaces with Mound A is significant since Sears (1982:186) considered it to be a habitation mound for religious specialists. It contains the greatest number of chipped-stone artifacts of all the excavated features at Fort Center (nearly 60 percent; see Appendix C). Steinen (1971:55, 1982:77, 92) contended that Mound A was a focus of craft specialists, and he specifically indicated that the large, broad-stemmed bifaces were used to saw wood and possibly shell or bone. My analysis of the use-wear on these implements generally supports Steinen's conclusions. Four of the eight Columbia points display rounding and polish on edge prominences along their lateral margins, and three exhibit striations oriented parallel to the long axes of their blades. This type of damage is indicative of cutting or sawing of relatively hard materials (Ballo 1992; Vaughn 1985). One of the bifaces has had its distal end steeply retouched on alternate margins suggesting secondary use as a drill; its tip is broken, however, and there is no observable use wear on the portion that remains. One of the Columbia points and the possible Broward/Ocala display impact-related damage at their distal ends and minimal wear on their lateral margins suggesting that they were used as projectiles.

The fact that: 1) many of these bifaces are made from exotic lithic materials that come from source areas located well over 200 km from Fort Center, 2) debitage of these raw materials are minimally represented at the site (see Table 31); and 3) these implements and raw materials are concentrated at a specific feature within the site (Mound A), suggest that these bifaces were acquired through exchange and were destined for use within a special context, that of craft specialists performing tasks related to the functioning of the ceremonial mound-pond complex.

Raw-Material Diversification

In this section I examine the degree to which diversification of the lithic resource base was practiced as a risk-abatement strategy within the study area. As discussed in Chapter 2, diversification can occur as a result of exploiting a wider range of resource types within a fixed geographic area or by enlarging the exploitable range to include more resource types. Two types of data are used to examine this question: temporally diagnostic hafted bifaces (i.e., projectile points), many of which come from surface-collected sites, and complete lithic assemblages from excavated or tested sites.

Regional Variability

Table 35 presents a breakdown of raw-material types (quarry clusters) for composite Archaic and post-Archaic assemblages in the Peace River and Kissimmee regions, as well as for Fort Center (8GL13) and Pineland (8LL33, 36, 37). When the Archaic and post-Archaic assemblages in the Peace River regions are compared there is a noticeable difference in the use of local (i.e., Peace River cherts) versus non-local materials. Sixty-four percent of the tools, cores, and debitage in post-Archaic assemblages are composed of Peace River cherts while only four percent of the Archaic assemblages contain this raw-material type. Although the sample of post-Archaic sites is small (N = 2), the increased use of local Peace River cherts has been documented at other post-Archaic sites in the region (e.g., Archaeological Consultants, Inc. 1994). The Archaic assemblage, on the other hand, is dominated by cherts from the Hillsborough River Quarry Cluster, with cherts from the Withlacoochee Quarry Cluster and silicified coral also present in significant amounts. A chi-square test of independence between the Archaic and post- Archaic assemblages indicates that these differences are statistically significant (X^2 obs = 654.035, $df = 4$, $p = <.0001$; in this and the following chi-square tests, Caladesi, Brooksville, Ocala, and Lower Suwannee/Lake Panasoffkee quarry clusters were combined because of low expected values in the individual cells. Unidentified cherts were not used in the chi-square analysis).

Table 35. Cross-tabulation of raw-material types (quarry clusters) by cultural components and geographic region.

Assemblages/ Regions	PR		HR		C		B		W		OC		LS/LP		SC		OTH/UID		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Archaic Assemblages																			
Peace River Region	42	4.00	640	60.95	17	1.62	15	1.43	123	11.62	8	.76	1	.10	122	11.62	82	7.81	1050
Kissimmee Region	426	50.18	185	21.79	9	1.06	16	1.88	66	7.77	13	1.53	1	.12	92	10.84	41	4.83	849
Kissimmee Region minus 8HG51	25	9.69	122	47.29	6	2.33	9	3.49	37	14.34	10	3.88	0	.00	30	11.63	19	7.36	258
Post-Archaic Assemblages																			
Peace River Region	242	64.02	70	18.52	0	.00	0	.00	3	1.16	4	1.06	9	2.38	25	6.61	25	6.61	378
Kissimmee Region	43	9.68	231	52.03	0	.00	0	.00	37	8.33	8	1.80	1	.23	61	13.74	63	14.19	444
8GL13	38	4.26	247	27.69	3	.34	0	.00	34	3.81	14	1.57	12	1.35	61	6.84	483[a]	54.15[a]	892
8LL33, 36, 37	0	.00	78	59.54	1	.76	0	.00	7	5.34	0	.00	5	3.82	10	7.63	30	22.90	131

KEY: PR = Peace River Quarry Cluster; HR = Hillsborough River Quarry Cluster; C = Caladesi Quarry Cluster; B = Brooksville Quarry Cluster, W = Withlacoochee Quarry Cluster; OC = Ocala Quarry Cluster; LS/LP = Lower Suwannee/Lake Pannasofkee Quarry Cluster; SC = Silicified Coral; OTH/UID = Other cherts and unidentified cherts.

[a] Includes 373 artifacts made from rounded chert cobbles; 41.82 percent of the site total.

In the Kissimmee region this pattern is reversed. Archaic assemblages exhibit the greatest dependence on Peace River cherts while post-Archaic assemblages are dominated by cherts from the Hillsborough River Quarry Cluster. However, this difference may be influenced by a single Archaic assemblage from the Driggers site (8HG51) on Lake Istokpoga, where Peace River cherts account for 68.2 percent of the tools and debitage (Appendix A). When this site is removed from the composite Archaic data set, the proportion of Peace River cherts at Archaic components drops to less than 10 percent (Table 35). This makes the proportional representation of raw-material types among the seven remaining Archaic assemblages more comparable to those in the Peace River region, with Hillsborough River cherts the most dominant followed by Withlacoochee cherts and silicified coral. Nonetheless, a chi-square test of independence indicates that there is a significant difference between these regional, Archaic period assemblages (X^2 obs = 29.044, *df* = 4, *p* = .0001; 8HG51 removed; cells with low expected values were combined as described above). Examination of the chi-square values for individual cells indicates that, even with 8HG51 removed, Peace River cherts occur in greater-than-expected amounts in the Kissimmee region Archaic assemblage, contributing to nearly 40 percent of the total chi-square value (11.129, or 38.32 percent).

When Archaic and post-Archaic assemblages in the Kissimmee region are compared there is little difference in the proportional representation of Peace River and Hillsborough River cherts. Silicified coral is well represented in the Kissimmee region post-Archaic assemblages, as it is in Archaic assemblages; however, there is a reduction in the proportional representation of all the other quarry clusters. A chi-square test of independence indicates that there is a significant difference between these two assemblages (X^2 obs = 16.234, *df* = 4, *p* = .0027; 8HG51 removed; cells with low expected frequencies were combined). Examination of the chi-square values for individual cells indicates that the cells that contribute the most to the total chi-square value are the Withlacoochee Quarry Cluster cherts and the combined Caladesi, Brooksville, Ocala, and Lower Suwannee/Lake Panasoffkee quarry cluster cherts. The Archaic assemblage has greater-than-expected values for these raw materials while the observed values for the post-Archaic assemblage are less than expected. This is reflected in Table 35 where the proportion of Withlacoochee cherts in the composite Archaic assemblage is roughly twice that of the post-Archaic assemblage. And while the absolute values are low, the proportions of Caladesi, Brooksville, and Ocala cherts in the Arcbaic assemblage are significantly higher than in the post-Archaic assemblage.

When the post-Archaic assemblages from the Peace River and Kissimmee regions are compared, significant differences are apparent. Peace River cherts are far more numerous in the Peace River assemblages while Hillsborough River cherts are dominant in the Kissimmee region assemblages. The other raw-material types are fairly similar in terms of their proportional representations; however, silicified coral and cherts from the Withlacoochee Quarry Cluster appear to be more common in the Kissimmee region assemblages than they are in the Peace River region. A chi-square test of independence confirms that the two regional post-Arcbaic assemblages are significantly different (X^2 obs = 272.725, $df = 4$, $p = <.0001$; cells with low expected values were combined), and the cells that contribute most to the total chi-square value in descending order are: Peace River, Hillsborough River, Withlacoochee cherts, and silicified coral.

Table 35 also compares the raw-material types that are present at Pineland and Fort Center. These assemblages were separated from the other post-Archaic assemblages because both sites are geographically located at much greater distances from all the major quarry clusters than are the sites in the Peace River, Kissimmee River, or Lake Wales Ridge areas. As this table reveals, the proportional representation of raw-material types at these two sites is very different. At Pineland, chert from a single quarry cluster, the Hillsborough, dominates the assemblage with nearly 60 percent of all lithic artifacts assigned to this raw-material category All other identifiable raw-materials contribute less than 10 percent each to the total assemblage.

In contrast, the most abundant raw material at Fort Center is the small chert cobbles and the artifacts made from them. The fabric and fossil content of most of the cobble material conforms to the identifying criteria for chert derived from the Tampa Member of the Miocene Hawthorn Group, although a few cobbles contain fossils diagnostic of cherts derived from the Suwannee and Ocala Limestones. The most likely source of these cobbles is the Hillsborough River Quarry Cluster (S. B. Upchurch, personal communication, 1993). While rounded, water-worn cobbles are not commonly associated with this region, small rapids and shoals are present in parts of the Hillsborough River and along Cow House Creek. Furthermore, the upper Hillsborough River flows through geographic regions containing exposures of Suwannee Limestone cherts and possibly some Ocala Limestone cherts as well (Upchurch et al. 1982a:132-133, 139, Figure 20E). Thus, the mixture of cobbles that possess characteristics of these chert-bearing formations along with the more common Tampa limestone cherts could have come from a single, secondary source deposit in the Hillsborough River. Another possibility is that the cobbles were collected along the shoreline of the Gulf of Mexico or along Tampa Bay. Some of the cobbles resemble a chert variety referred to as Type 4 chert (Goodyear et al. 1983:58; see Chapter 7), which is commonly found in these areas. The Peace River also is a possible source location, although the absence of any phosphate pellets in the interior fabric of the nodules would seem to argue against this.

Since the exact provenience of the cobbles is uncertain, they have been included in the "Other" category in Table 35; however, a total of 373 artifacts were made from this material accounting for 41.82 percent of the total assemblage. Second in abundance at nearly 28 percent are cherts that can be definitely attributed to the Hillsborough River Quarry Cluster. This proportion could actually be higher if the rounded chert cobbles were obtained from this quarry cluster Although the remaining chert types are not abundant, they are consistently represented, and the range of types is much greater than at Pineland.

Both Pineland and Fort Center also contain small amounts of raw materials acquired locally such as quartz, dolomite, and fossil bone (Appendix B) which have also been included in the "Other" category in Table 35. None of these materials is especially good for manufacturing chipped-stone implements; however, all were used sparingly in the chipped-stone industries at these sites. Dolomite, or calcium magnesium carbonate, is a common mineral that occurs in many sedimentary rock formations in Florida (Scott 1992). Sedimentary rock composed primarily of dolomite sometimes forms a secondary weathering rind through the process of reprecipitation (S. B. Upchurch, personal communication, 1993). This rind can be very hard and may possess some of the same characteristics (e.g., conchoidal fracturing) as chert, for which it is sometimes mistaken. But because it contains no or very little silica, dolomite is less durable than chert making it a poor material for tool production. Fossil bone is often found on prehistoric sites, but because it is brittle, it was rarely used for manufacturing tools.

All but one of the quartz artifacts at Fort Center are flattened, discoidal pebbles that may be derived from the Citronelle Formation that underlies the Lake Wales Ridge. A few have been split longitudinally and exhibit battering damage on their opposing ends, possibly as a result of bipolar reduction. One quartz projectile point appears to have been manufactured from quartz imported from outside the state.

In addition to these materials, both Pineland and Fort Center have large numbers of non-chipped stone including unsilicified limestone and sandstone, some of which has been fashioned into ornaments or used as grinding or abrading stones (Austin 1995a, Steinen 1982:81-82, 93). Artifacts

Table 36. Lithic raw-materials (quarry clusters) present at Yat Kitischee (8PI1753).

Raw-Materials	N	Percent
Turtlecrawl Point QC	153	33.85
Hillsborough River QC	215	47.57
Caladesi QC	18	3.98
Brooksville QC	0	0.00
Withlacoochee QC	8	1.77
Ocala QC	0	0.00
Lower Suwannee/Lake Panasoffkee QC	0	0.00
Silicified Coral	27	5.97
Other/Unidentified	31	6.86
Totals	452	100.00

made from non-Florida stone such as granite, quartz crystal, diorite, gneiss, and rhyolite also are present, particularly at Fort Center (Steinen 1982:81, 83).

It is worth comparing these two assemblages to the lithic assemblage at Yat Kitischee (Table 36), which is located near several productive chert-bearing deposits. Not surprisingly, these local chert sources were exploited most heavily, with cherts from the Hillsborough River and Turtlecrawl Point quarry clusters having the greatest representation. Most of the Hillsborough cherts were probably obtained from outcrops around Tampa Bay. Fossiliferous Type 4 chert, which is the most abundant of the identifiable Hillsborough River types in this assemblage (34.43 percent of the total Hillsborough River Quarry Cluster cherts; see Appendix B), is common in outcrops around Tampa Bay (cf. Goodyear et al. 1983:Figure 12). Other local materials include fossil bone, sandstone, and non-siliceous limestone (Austin 1995b). Cow House Creek chert, obtainable only from outcrops in northeastern Hillsborough County, is present in moderate amounts (9.84 percent of the total Hillsborough River Quarry Cluster cherts) indicating importation of this material via trade or direct procurement. No Peace River, Brooksville, Ocala, or Lower Suwannee/Lake Panasoffkee quarry cluster cherts are present, and cherts from the Withlacoochee Quarry Cluster are minimally represented. Silicified coral is present, but not in very great amounts. Clearly, the acquisition pattern at Yat Kitischee is one of reliance on locally available materials. The only truly exotic lithic material is a small piece of steatite (Austin 1995b:197).

Summary. The biggest regional difference in the use of lithic raw materials occurs during the post-Archaic period. Sites in the Peace River region were dependent on local Peace River Quarry Cluster cherts while sites in the Kissimmee region contain much higher quantities of Hillsborough River Quarry Cluster cherts. With the exception of one site, 8HG51, Archaic assemblages in the Peace River and Kissimmee region possess relatively similar representations of these two chert types.

The most significant pattern that is indicated by these data is the increased reliance on locally available materials during the post-Archaic period. This is reflected best by sites in the Peace River region, where the composite post-Archaic assemblage contains a much higher percentage of locally available Peace River Quarry Cluster cherts than the composite Archaic period assemblage. This dependence on local raw materials is consistent with an acquisition strategy of direct procurement by hunter-gatherers that were logistically organized and who operated within a restricted territory.

At Pineland, Fort Center, and Yat Kitischee there is abundant evidence for the use of local limestones, dolomites, sandstones, quartz pebbles, and fossil bone. These materials rarely occur at Archaic period sites in the region and their absence cannot be attributed to problems of preservation. The increased dependence on non-siliceous stone is due, in part, to functional requirements such as the use of sandstone and limestone as abrading stones. However, there also is evidence for the occasional use of non-siliceous or low-quality silicified stone in the chipped-stone industries of these sites. Waste flakes of fossil bone, quartz, and dolomite are present at these sites and this suggests that attempts were being made to experiment with lower-utility materials that were available locally. This can be interpreted as a response to reduced access to high-utility resources. For the residents of Pineland and Fort Center, this reduced access was a consequence of distance, but at Yat Kitischee it appears to be the result of expediency in response to time-stress since higher-utility materials were available at relatively nearby source locations

Temporal Variability

In order to examine temporal variation in resource diversity, I have analyzed two sets of data: temporally diagnostic hafted bifaces and complete lithic assemblages. The statistical methods used in this section are discussed in Chapter 7. Two assumptions underlie analyses of assemblage diversity: 1) that the individual specimens have all been classified to the same taxonomic level, and 2) that the categories (taxa or types) are mutually exclusive (Peet 1974:286). In order to meet these assumptions, I have chosen to compare Archaic and post-Archaic assemblages on the basis of quarry-cluster assignments since this is the lowest taxonomic level to which all specimens can be unambiguously assigned. The "unidentified category" is not used since it is not possible to know if the individual specimens assigned to this category represent as yet unidentified chert types, or are perhaps atypical examples of chert types from quarry clusters already represented in the study collection. Non-chert materials also are not included.

The hafted-biface assemblage consists of 178 specimens from 31 sites which include both surface-collected and excavated or tested sites. Table 37 lists the various Archaic and post-Archaic hafted-biface types cross-tabulated by raw-material type (i.e., quarry clusters) along with assemblage totals. It should be noted that Archaic hafted bifaces from Fort Center and Pineland are not included in the Archaic assemblage totals. This was done so that the raw materials represented by these artifacts could be compared with those in the overall Archaic hafted-biface assemblage. Calculated measures of richness and evenness for each assemblage are presented in Table 38 and a bivariate plot of these

Table 37. Cross-tabulation of temporally diagnostic hafted bifaces by raw-material types (quarry clusters).

Hafted-Biface Type	Quarry Clusters								Totals
	LS/LP	O	W	B	HR	C	PR	SC	
Archaic Types									
Alachua								2	2
Bolen					7				7
Culbreath			1		1				2
FAS^a	1		4	1	3	1		1	11
Greenbriar					2				2
Hardee			2		1				3
Hillsborough								1	1
Kirk				1				1	2
Levy		1	3	2	8			4	18
Marion		1	2	5	8	1	1	7	25
Newnan			4	2	4		2	15	27
Putnam		1		2	4			3	10
Sumter		1	1	1		1		1	5
Totals	1	4	17	14	38	3	3	35	115
Percent	0.87	3.48	14.78	12.17	33.04	2.61	2.61	30.43	100.00
Post-Archaic Types									
Bradford			2		1				3

Table 37 (Continued).

Hafted-Biface Type	Quarry Clusters								Totals
	LS/LP	O	W	B	HR	C	PR	SC	
Broward?	1		1		2				4
Citrus	1	1							2
Columbia	6				1				7
Copena?			1						1
Duval	1		2						3
Hernando			1		10			1	12
Jackson	1				1			2	4
Ocala			1		1				2
Pinellas					8		7	1	16
Sarasota	1								1
Tampa					1				1
Taylor					1				1
Westo?			4					2	6
Totals	11	1	12	0	26	0	7	6	63
Percent	17.46	1.59	19.05	0.00	41.27	0.00	11.11	9.52	100.00

KEY: LS/LP = Lower Suwannee/Lake Panasoffkee; O = Ocala; W = Withlacoochee; B = Brooksville; HR = Hillsborough River, C = Caladesi; PR = Peace River, SC = Silicified Coral

[a] Florida Archaic Stemmed; stemmed points that could not be assigned with confidence to any of the four sub-types (Alachua, Levy, Marion, or Putnam).

Table 38. Richness (*R*) and evenness (*E*) values for temporally diagnostic hafted bifaces.

Assemblage	N	QC[a]	*R*	Mean	SD	CV	*E*
Archaic	115	8	10.00	14.38	14.81	1.03	8.97
Post-Archaic	63	6	7.50	7.88	8.71	1.11	8.89

[a] Number of quarry clusters represented in the hafted-biface assemblage.

data is presented in Figure 44 (see Chapter 7 for a discussion of how richness and evenness measures were calculated).

Although the measures of evenness are nearly identical, the Archaic assemblage is more diverse since it contains more raw-material types (i.e., high richness). While the post-Archaic assemblage contains fewer raw-material types, the distribution of specimens between these raw-material types is relatively even with just over 57 percent of the 63 hafted bifaces assigned to four of the quarry clusters while another 41.27 percent is assigned to the Hillsborough River Quarry Cluster. This results in a relatively high measure of evenness, although still lower than the Archaic assemblage.

While these data seem to indicate a slight decrease in raw-material diversity during the post-Archaic period, the discrepancy in sample sizes between the Archaic and post-Archaic assemblages may have affected class richness (cf. Jones et al. 1983; Kintigh 1984, 1989). Consequently, the Archaic sample could contain more raw-material types simply because it is three times as large as the post-Archaic sample. To see if this was true, an expectation for richness based on sample size was developed by generating simulated assemblages of various sizes and comparing the actual richness values of the archaeological samples to the expected richness values for specific sample sizes. The simulated assemblages were generated using Kintigh's (1994) DIVERS program (see discussion in Chapter 7). Two hundred simulated samples were randomly generated for sample sizes ranging from 1 to 200. The resulting mean (expected) values are indicated by the center line in Figure 45. The dashed lines indicate the 90 percent confidence interval around the means of the simulated samples, i.e., the range within

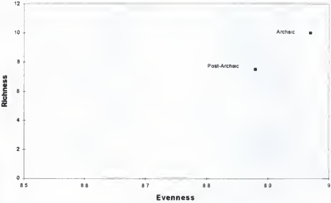


Figure 44. Bivariate plot of richness (*R*) and evenness (*E*) measures for Archaic and post-Archaic hafted-biface assemblages.

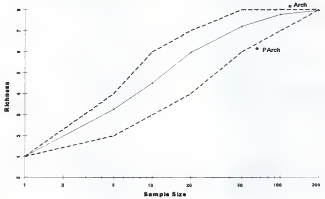


Figure 45. Relationship between number of raw-material types (richness) and sample size for Archaic and post-Archaic hafted-biface assemblages. Sample size has been plotted on a logarithmic scale to produce a more interpretable plot.

which 90 percent of all the random simulations fell. The actual richness values for the two cultural-temporal assemblages of hafted bifaces also are shown (richness in this figure is represented simply by the number of raw-material types present in a sample/assemblage).

As Figure 45 demonstrates, the Archaic assemblage is above the 90 percent confidence band indicating that raw-material richness is greater than would be expected given its sample size. The post-Archaic assemblage lies below the 90 percent confidence band, indicating that richness for this assemblage is lower than expected for its sample size.

This distinction between Archaic and post-Archaic assemblages is even more apparent when all lithic artifacts (i.e., tools, debitage, cores, and hammerstones) from the excavated and tested site components are compared. Table 39 provides the raw data for Archaic and post-Archaic assemblages in the Peace River and Kissimmee regions, respectively (minus unidentified and non-chert materials). Also shown are assemblage data from Fort Center and Pineland (minus Archaic-style hafted bifaces). Calculated richness and evenness measures for these assemblages are presented in Table 40 and a bivariate plot is shown in Figure 46. Again, the Archaic assemblages prove to be the most diverse with high measures of both richness and evenness when compared to all of the post-Archaic assemblages. Comparison of these archaeological assemblages with 200 simulated assemblages ranging in size from 1 to 2000 indicates that all of the post-Archaic assemblages except Pineland (8LL33, 36, 37) possess richness values that are well below the 90 percent confidence interval for their individual sample sizes (Figure 47), while Pineland's assemblage lies very close to the lower limit of the 90 percent confidence interval. On the other hand, both of the composite Archaic assemblages are positioned above the 90 percent confidence interval for their assemblage sizes These results indicate that raw-material diversity among the post-Archaic assemblages in the study area is lower than among the Archaic assemblages. Moreover, they support the results of an earlier study using a smaller sample of temporally diagnostic hafted bifaces from the Lake Wales Ridge area which indicated a similar reduction in raw-material

Table 39. Raw-material types (quarry clusters) represented in regional Archaic and post-Archaic lithic assemblages.

Assemblages	Quarry Clusters								Totals[a]
	LS/LP	O	W	B	HR	C	PR	SC	
Archaic									
Kissimmee Region	1	13	66	16	185	9	426	92	808
Peace River Region	1	8	123	15	640	17	42	122	968
Totals	2	21	189	30	827	24	468	214	1775
Percent	.11	1.18	10.65	1.69	46.59	1.35	26.37	12.06	100.00
Post-Archaic									
Kissimmee Region	1	8	37	0	231	0	43	61	381
Peace River Region	9	4	3	0	70	0	242	25	353
Totals	10	12	40	0	301	0	285	86	734
Percent	1.36	1.63	5.45	.00	41.01	.00	38.83	11.72	100.00
Fort Center[b]	12	14	31	0	241	3	38	50	389
Percent	3.08	3.60	7.97	0.00	61.95	0.77	9.77	12.85	100.00
Pineland[c]	5	0	7	0	78	1	0	8	99
Percent	5.05	.00	7.07	.00	78.79	1.01	.00	8.08	100.00

KEY: LS/LP = Lower Suwannee/Lake Panasoffkee; O = Ocala; W = Withlacoochee; B = Brooksville; HR = Hillsborough River; C = Caladesi; PR = Peace River, SC = Silicified Coral

[a] Totals do not include unidentified cherts or non-chert stone.

[c] Does not include Archaic hafted bifaces.

[b] Does not include cobble chert or Archaic hafted bifaces.

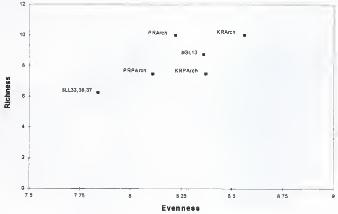


Figure 46. Bivariate plot of richness (*R*) and evenness (*E*) measures for regional Archaic and post-Archaic lithic assemblages.

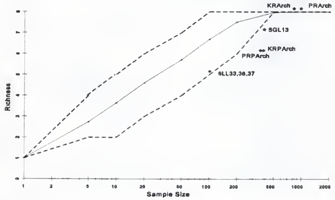


Figure 47. Relationship between number of raw-material types (richness) and sample size for regional Archaic and post-Archaic lithic assemblages. Sample size has been plotted on a logarithmic scale to produce a more interpretable plot.

Table 40. Richness (*R*) and evenness (*E*) values for regional Archaic and post-Archaic lithic assemblages.

Assemblages	N[a]	QC[b]	*R*	Mean	SD	CV	*E*
Archaic							
Kissimmee Region	808	8	10.00	101.00	145.12	1.44	8.56
Peace River Region	968	8	10.00	121.00	215.00	1.78	8.22
Post-Archaic							
Kissimmee Region	381	6	7.50	47.63	77.66	1.63	8.37
Peace River Region	353	6	7.50	44.13	83.34	1.89	8.11
Fort Center[c]	389	7	8.75	48.63	79.66	1.64	8.36
Pineland[d]	99	5	6.25	12.28	26.72	2.16	7.84

[a] Totals do not include unidentified cherts or non-chert stone.

[b] Number of quarry clusters represented in the hafted-biface assemblage.

[c] Does not include cobble chert or Archaic hafted bifaces.

[d] Does not include Archaic hafted-bifaces.

diversity during the post-Archaic period. This decrease was attributed to a reduction in residential mobility (Austin 1996b).

The raw materials represented by the Archaic-style hafted bifaces at Pineland and Fort Center are much less diverse than the overall Archaic sample (Table 41), although the raw materials that are represented are those that are most abundant in the Archaic assemblage. Among the 22 Archaic-style hafted bifaces in these two assemblages, silicified coral (59.09 percent) and Hillsborough River Quarry Cluster cherts (27.27 percent) are the most common raw materials followed by cherts from the Withlacoochee Quarry Cluster (13.64 percent).

It should be noted that non-chert materials such as quartz, fossil bone, and dolomite were not included in the above analysis. At Fort Center, these materials account for a combined 3.27 percent of

Table 41. Raw-material types (quarry clusters) represented by the Archaic-style hafted bifaces at Fort Center (8GL13) and Pineland (8LL33, 36, 37).

Site	Withlacoochee QC	Hillsborough River QC	Silicified Coral	Totals
8GL13	3	6	11	20
8LL33, 36, 37			2	2
Totals	3	6	13	22
Percent	13.64	27.27	59.09	100.00

the total lithic assemblage while at Pineland they account for a combined 9.16 percent. The only other assemblage from the study area that contains these materials is 8HR92, where one angular fragment of dolomite was recovered. Moreover, chert cobbles and related waste debris account for nearly 42 percent of the total lithic assemblage at Fort Center. To determine what effect the inclusion of these materials would have on assemblage diversity, richness and evenness values were recalculated for the excavated assemblages with quartz, dolomite, and fossil bone included as separate raw-material classes. The 373 artifacts made from cobble cherts were added to the Hillsborough River Quarry Cluster artifacts from Fort Center since this is the suspected source area. The results are shown in Table 42 and Figure 48. Not surprisingly, since Fort Center is the only site that contains all three of the added lithic materials, it displays a high richness value; however, because 614 of the 791 artifacts are now included in the Hillsborough River Quarry Cluster, the evenness value is the lowest of all four assemblages. This suggests that although a wider variety of raw materials was being used, the emphasis was on using cherts obtained from a single quarry cluster or, if the cobbles are from another source area, two quarry clusters. Even with the inclusion of non-chert materials, however, Archaic assemblages remain the most diverse because both the richness and evenness values are high.

Summary. The data presented above indicate that not only were post-Archaic lithic assemblages less diverse than Archaic assemblages in terms of the use of chert resources, but post-

Table 42. Richness (*R*) and evenness (*E*) values for Archaic and post-Archaic assemblages with non-chert materials included.

Assemblages	N	RM[a]	*R*	Mean	SD	CV	*E*
Archaic[b]	1777	9	8.18	161.55	268.85	1.63	8.37
Post-Archaic[b]	734	6	5.45	66.73	114.93	1.72	8.28
Fort Center[c]	791	10	9.09	71.91	180.49	2.51	7.49
Pineland[c]	111	7	6.36	10.09	22.86	2.27	7.73

[a] Number of chert quarry clusters and non-chert resources (i.e., quartz, dolomite, and fossil bone) represented in the assemblage. Cobble chert also is included as a separate raw-material class.

[b] Assemblages from Peace River and Kissimmee regions have been combined.

[c] Archaic hafted bifaces not included.

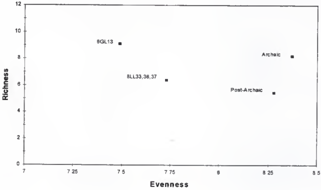


Figure 48. Bivariate plot of richness (*R*) and evenness (*E*) measures for Archaic and post-Archaic assemblages with the addition of non-chert materials

Archaic populations were more dependent on Hillsborough River cherts than Archaic populations There also was an increase in the use of lower-utility Peace River cherts during the post-Archaic When non-chert materials are considered, Fort Center stands out as having a wider range of resources, yet the technological emphasis remained on cobble cherts and cherts obtained from the Hillsborough River Quarry Cluster. The fact that this increase in resource richness is due to the use of lower-utility resources is significant and is analogous to the increased dependence on local resources by post-Archaic groups occupying the Peace River basin, as discussed above.

Thermal Alteration and the Reduction of Procurement Risk

In Table 43, Archaic and post-Archaic hafted bifaces are compared with regard to the use of thermal alteration. The data indicate a significantly higher incidence of intentional heat treatment among Archaic period hafted bifaces. These data are consistent with those of Ste. Claire (1987) who has argued that the increased dependence on thermal alteration during the Archaic period was an adaptive response to the necessity of exploiting marginal habitats where high-quality lithic materials were in short supply. In effect, the use of this technology enabled a wider range of lithic resources to be used and so can be conceived of as a risk-abatement strategy.

Ste. Claire's hypothesis is consistent with optimal-foraging theory which predicts that a decline in resource density will result in an increase in resource breadth as more lower-ranked resources are exploited. If the resource in question is siliceous raw materials, then the use of less desirable chert types should increase as outcrops containing high-quality cherts become more scarce. Under these conditions, thermal alteration might be expected in order to enhance the technological and functional properties of these poorer-quality resources. Adopting this strategy should only occur, however, when the marginal return, in terms of labor efficiency, for the existing strategy is equal to or less than the average return for the new strategy Or, in other words, when the search and transport costs associated with the exploitation of the higher-ranked resource become excessive.

Table 43. Presence of thermal alteration among Archaic and post-Archaic hafted bifaces.

Cultural Period	Thermal Alteration						Totals[a]	
	Present		Possible		Absent			
	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Archaic	58	38.93	9	6.04	82	55.03	149	100.00
Post-Archaic	9	11.69	3	3.90	65	84.42	77	100.00

X^2 obs = 19.882, $df = 2$, $p = < .0001$

[a] Includes all temporally diagnostic hafted bifaces from excavated and surface-collected assemblages.

Through optimization analysis it is possible to model the effects of increased transportation costs on the average, total, and marginal returns for the two alternative strategies by increasing the amount of time necessary to travel to and from the raw-material source while at the same time keeping all other costs constant. This increase in travel costs becomes, in effect, a proxy measure for the decreasing availability of high-quality material; in other words, material that does not require thermal alteration. Estimations of the labor costs associated with travel, procurement, and production (including the time necessary to effectively alter siliceous materials) are presented in Table 44. All costs are initially considered as fixed. This allows me to arrive at a base estimate of labor efficiency, and then vary the cost of various components of the production process to evaluate the effect on total, average, and marginal returns. It also is necessary to specify the goal in quantitative terms, so for this analysis I will assume that the goal is to maximize the efficient production of 10 bifacial implements.

It must be emphasized that the estimates of labor time used in this analysis are for purposes of illustration only. Justifications for their derivation and use are given below, and are based on a number of simplifying assumptions that are also specified. Varying the absolute values to increase authenticity should not alter the results of the analysis significantly since it is the relative relationship between transportation, processing, and thermal alteration costs that is important.

Table 44. Estimates of biface production costs

Task	Labor Time in Hours
Production Goal = 10 Bifacial Implements	
Transportation[a]	.50
Collection[a]	1.00
Processing	.50
Thermal Alteration[a]	
Collecting wood	2.00
Digging the pit	.25
Starting and tending the fire	1.00
Layering of sand with bifaces	.25
Starting and tending the second fire	.75
Periodic tending of the fire during heat alteration	2.50
Failure Rate	
Unaltered material	20 percent
Altered material	5 percent

[a] Fixed costs, averaged over total output.

Transportation costs refer to the time spent traveling to and from a chert source. I assume that the individual is traveling from and will return to a residential location. I will further assume that this residential location is situated within a chert-rich area such that travel to a source of high-quality material can be accomplished in 15 minutes, making the total transportation cost for one procurement trip equal to 30 minutes or .5 hours. Initially, transportation costs will be considered fixed costs in that it takes the same amount of time to travel to and from the quarry irrespective of the number of bifaces produced. Thus, the cost of transportation must be averaged over the total number of bifaces produced; in this case, 10 per trip for an average transportation cost of .05 hours per biface. Collection costs are those associated with actually procuring the raw material at its source. This may include time spent searching for desirable material, digging and exposing the material so that it can be worked, removing large blocks of stone from boulders, nodules, or exposed beds, gathering nodules from the landscape for use as cores, and finally, core reduction. The amount of time necessary to accomplish these tasks is difficult to estimate since many factors affect the time spent on a specific collection trip. To simplify the analysis, however, collection time is arbitrarily set at one hour This too is considered a fixed cost that is averaged between the number of bifaces that are eventually produced.

Processing of lithic material consists of two components. Initial processing often occurs at the quarry where flake blanks are produced and worked into rough bifacial form before being transported back to the residential camp. The second processing step often occurs at the residential site. This involves reduction of the biface blank or preform into a functional implement. In this analysis, both components have been combined into a single variable representing total processing costs.

Calculation of processing costs is based on replication experiments conducted by Callahan (1979:31) who estimates a time range of 14-40 minutes to produce a typical Clovis biface, or an average of 34 minutes. The minimum time achieved by Callahan was approximately 26 minutes. While the type of biface, intended use, hafting needs, raw-material characteristics, and skill level of the knapper all affect the amount of time necessary to accomplish the processing task, a time range of 20-40 minutes is usually considered typical for the production of most hafted bifaces. Thus, the figure of 30 minutes, or .5 hours per biface, used here is felt to be reasonably accurate.

To examine the effect of adding thermal alteration to the production process, it is necessary to include its cost in the computation. A review of various thermal alteration experiments indicates that the amount of time necessary to adequately heat treat lithic materials is variable, ranging from 13 to 48 hours (Ahler 1983:3; Bond 1981:11-12; Hellweg 1984:28; Joyce 1985:36, Mandeville 1973:190-199; Purdy 1974:37-46; Rick 1978 20-21, Figure 5). Not all of this time requires an expenditure of labor, however. A large part of the labor investment occurs before the heat-treating process begins, that is, while digging the pit, collecting the firewood, burying the blanks or preforms, and building the fires (Hellweg 1984:24-27). Once a layer of coals has been created, and the bifaces have been buried under a second fire, close but not constant attention needs to be paid to tending the second fire so that the correct temperature is achieved and maintained for the necessary duration. Once the fire has burned for the appropriate period of time, it can be allowed to burn out and cool off unattended. Although precise time figures for these tasks are not available, the values in Table 44 are offered as reasonable estimates. Summing the time estimates for the various activities associated with thermal alteration results in a total estimate of 6.3 hours of actual labor time. As with transportation and collecting costs, the cost of thermal alteration is fixed and is averaged between all of the implements produced using the altered material.

The final factor to consider is the greater ease in flaking that results from altering the original lithic material. Conceivably, this could reduce the amount of time necessary to manufacture a biface, and thus reduce the overall production costs associated with thermal alteration. Although I could find no timed comparisons of flint knapping with heat-treated versus non-heat-treated material, it is possible to approximate this increase in efficiency by using a multiplier that represents the potential reduction of biface failures using thermally altered stone. Rick (1978) conducted flintknapping experiments on thermally altered and non-thermally altered lithic materials from Illinois and documented the number of production failures that resulted using the different materials. For unaltered material, he experienced a failure rate of 22 percent (4 out of 18) while for heat-treated material the failure rate was only 5 percent (1 out of 20) (Rick 1978:70). I have rounded off the failure rate for unaltered material to 20 percent and included both of these failure rates in Table 44.

Determining the total labor cost involved in biface production can be accomplished by summing the costs associated with each phase of the production process and multiplying the total by the failure rate as shown in the following formula:

$$U = [(T \div N) + (C \div N) + P + (TA \div N)] \times F$$

where T = transportation costs, C = collection costs, P = processing costs, N = the total number of items produced, TA = the cost of thermal alteration (which will equal 0 if it is not employed), F = the failure rate, and U = unit cost, or the cost to produce a single biface. Using this formula, it is possible to model the effect of increasing transportation costs on the total, average, and marginal returns of biface production strategies that employ altered and unaltered lithic materials (Table 45).

Obviously, if there is no change in cost such that the average rate of return neither increases nor decreases, then marginal returns will remain constant. However, if travel to and from a source location is increased by .5 hours, then the effect during the second hour of production is an overall decrease in average and marginal returns (Table 45). If .5 hours of transportation costs are added to each succeeding hour of production, the effect is a gradually diminishing rate of total returns (Figure 49). Since the only variable that is being manipulated is travel time, the effect of increasing distance to lithic raw materials is an almost immediate decline in both average and marginal returns.

When the average and marginal returns of the two strategies are compared (Figure 50), it is apparent that after the fifth hour of labor time (i.e., after an extra 2.5 hours of transport time have been added to the total cost of production), the marginal return for the strategy employing unaltered material has declined to the point that it equals the average return for the more labor-intensive strategy of employing thermal alteration on raw materials that "cost" only .5 hours to transport. By hour 6, the extra hour of work effort is only netting an additional .65 bifaces because of the increase in the cost of transport by an additional .5 hours (for a total of 3 hours) as compared to an average return of .72 bifaces for a strategy employing thermal alteration. From this point on, although the average and marginal returns for both strategies decline, the strategy employing thermal alteration on materials that are located in close proximity always results in higher returns than a strategy employing unaltered

Table 45. Effect of increasing transportation costs on the average, total, and marginal returns for biface-production strategies that employ unaltered and thermally altered lithic materials.

Unit of Labor Time[a]	Unaltered Material				Thermally Altered Material			
	Average Return	Total Return	Marginal Return	Hours to Produce 10 Bifaces	Average Return	Total Return	Marginal Return	Hours to Produce 10 Bifaces
0	0	0	0		0	0	0	
1	1.28	1.28	1.28	7.8	.74	.74	.74	13.4
2	1.19	2.38	1.10	8.4	.72	1.43	.69	14.0
3	1.11	3.33	.95	9.0	.69	2.07	.64	14.5
4	1.04	4.17	.83	9.6	.67	2.66	.59	15.0
5	.98	4.90	.74	10.2	.64	3.22	.55	15.5
6	.93	5.56	.65	10.8	.62	3.73	.52	16.1
7	.88	6.14	.58	11.4	.60	4.22	.48	16.6
8	.83	6.67	.53	12.0	.58	4.67	.45	17.1
9	.79	7.14	.48	12.6	.57	5.10	.43	17.6
10	.76	7.58	.43	13.2	.55	5.51	.40	18.2
11	.72	7.97	.40	13.8	.54	5.89	.38	18.7
12	.69	8.33	.36	14.4	.52	6.25	.36	19.2
13	.67	8.67	.33	15.0	.51	6.59	.34	19.7

Table 45 (Continued).

Unit of Labor Time[a]	Unaltered Material				Thermally Altered Material			
	Average Return	Total Return	Marginal Return	Hours to Produce 10 Bifaces	Average Return	Total Return	Marginal Return	Hours to Produce 10 Bifaces
14	.64	8.97	.31	15.6	.49	6.91	.32	20.3
15	.62	9.26	.28	16.2	.48	7.22	.31	20.8
16	.60	9.52	.26	16.8	.47	7.51	.29	21.3
17	.57	9.77	.25	17.4	.46	7.78	.28	21.8
18	.56	10.00	23	18.0	.45	8.05	.26	22.4
19	54	10.22	.22	18.6	.44	8.30	.25	22 9
20	.52	10.42	.20	19.2	.43	8.54	.24	23 4

[a] For each unit of labor time over 1 hour, an additional .5 hours of travel time has been included in the computation of returns.

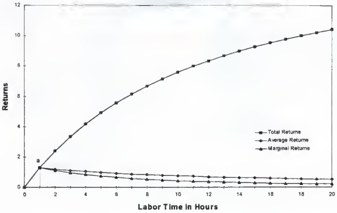


Figure 49. Effect of transportation costs on total, average, and marginal returns employing a production strategy without the use of thermal alteration. The optimal labor effort is indicated by (a) where average and marginal returns are at their highest.

materials that must be obtained at distances greater than a 3-hour walk. Figure 51 provides a similar comparison using average and marginal costs rather than returns.

What this model suggests is that, due to the large amount of labor input involved in heat treating chert, its use only becomes efficient when transport times are low. The fact that the point of diminishing marginal returns occurs so rapidly in Figure 49 underscores the importance of transport costs in modeling lithic economies. Yet despite this, the high production costs associated with thermal alteration outweigh the advantages of employing it until the transport costs associated with procuring high-quality materials becomes excessive, as indicated by Figures 50 and 51. When the time necessary to travel to and from these sources increases, and there is less desirable material close at hand, then it becomes economically feasible to use thermal alteration on poorer-quality material.

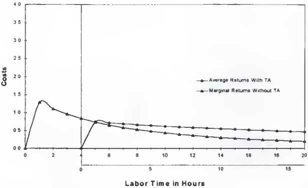


Figure 50. Comparison of marginal and average return curves for competing biface-production strategies. A switch in strategies should occur at the point at which thermal alteration of lithic raw materials in close geographic proximity to the forager results in an average return that is equal to or greater than the marginal return of a strategy employing unaltered lithic materials obtained from a distant source.

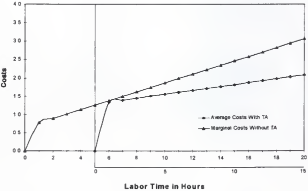


Figure 51. Comparison of marginal and average cost curves for competing biface-production strategies.

Summary. The optimization model suggests that the effect of differential raw-material availability on labor efficiency is an important factor influencing the decision to switch to a production strategy that employs thermal alteration. Under conditions of limited access to high-quality chert resources and ready access to sufficient supplies of poorer-quality resources, the use of thermal alteration on these poorer-quality materials may result in an increase in labor efficiency when compared to the alternative strategy of procuring better-quality cherts that are limited in their distribution or located at a distance. In effect, thermal alteration is a strategy for increasing resource breadth and reducing the risk of procurement failure.

Scavenging, Reuse, and Recycling

The discarded artifacts present at previously occupied campsites and residential sites represented a source of raw material to groups inhabiting areas where natural outcrops of chert were limited or non-existent. The types of artifacts that would be expected to be scavenged and either reused or recycled are cores, hammerstones, broken and discarded bifaces, and larger flakes. Although evidence for the reuse and recycling of all of these artifact classes is present in the study area, I focus here on bifacial implements.

The most obvious indicators of scavenging behavior are hafted bifaces that possess remnant features that enable one to identify the broken bifacial form that was used to create a functional implement (Figure 52). Examination of hafted bifaces from the study area indicate that both distal and proximal fragments were scavenged, reworked, and then reused. The features that enable identification of a reworked distal fragment include: 1) the retention of a portion of the flat, medial fracture plane on the base of the new stem, 2) roughly shaped basal-blade edges, and 3) basal flake scars that end in hinge terminations (Figure 53 a-e) Proximal fragments that have been reworked distally have a blade that is proportionately much shorter than the basal-blade width (Figure 53 f-h). The reuse of proximal

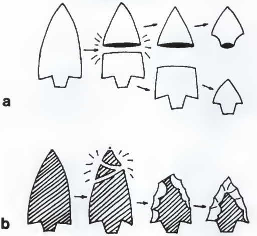


Figure 52. Biface scavenging and reuse: a) reduction of proximal and distal fragments into functional implements; b) differential patination on scavenged and reworked biface.

fragments is sometimes difficult to distinguish from unbroken bifaces that have experienced prolonged distal resharpening, however, the flake-scar patterns on the scavenged artifacts usually are less refined than the original manufacture scars and are larger than typical retouch scars (Tesar 1994). Both proximal and distal forms may exhibit differential patination with older, unflaked portions appearing more weathered or less lustrous than more recent flake scars (Figures 52 and 53). This provides almost conclusive proof that a biface has been reworked from an older fragment.

A second form of scavenging occurred when the broken edges of biface fragments were used as expedient tools or were retouched to create a completely new tool form. The high-angled fracture planes formed by typical transverse or longitudinal breaks make excellent scraping edges and most of the tools with edge-damage along these broken margins were used in this fashion. The juncture of the fracture plane and the remnant bifacial tool margin sometimes forms a sturdy, sharp projection that was used as a drill or graver. Finally, a few biface fragments exhibit retouch along broken margins (Figures

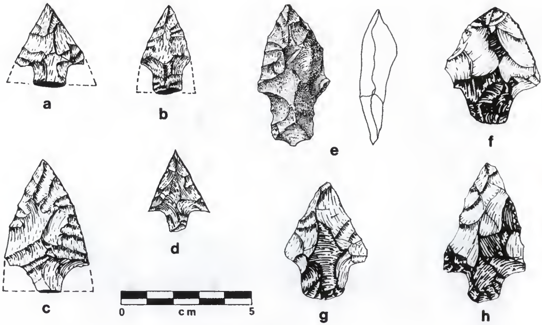


Figure 53 Archaeological examples of the reuse of scavenged bifaces: a-e) reworked distal fragments; f-h) reworked proximal fragments Proveniences: a-c, f-h) 8GL13; d) 8HG688; e) 8HG767.

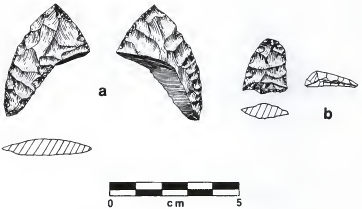


Figure 54. Examples of recycled bifaces: a) distal fragment retouched along broken margin and use as a scraper; b) stem fragment retouched along broken margin and used as an end scraper. Proveniences: a) Lake Livingston; b) State Road 70.

43c, 54). The most unusual is a stem that has had its broken margin retouched to make a small end-scraper (Figure 54b). These types of scavenging represent a form of recycling since bifacial implements were used in ways that were unintended by the original manufacturers.

Many of the artifacts from the study area that exhibit evidence of reuse and recycling are found in the surface-collected assemblages. Although some of the hafted bifaces resemble typical Archaic stemmed projectile-point varieties, and were found in association with other diagnostic Archaic period hafted-biface types, post-Archaic hafted bifaces and ceramics often were found at these sites as well. Therefore, it is not possible to state with certainty whether the scavenging was done by Archaic or post-Archaic peoples. It is possible that hunter-gatherers occupying the study area during both culture periods scavenged artifacts and reused them in similar ways.

Table 46. Data on the numbers of reused and recycled bifaces in Archaic, post-Archaic, and surface-collected assemblages

Assemblages	Reused	Possibly Reused	Recycled	All Other Bifaces	Totals
Archaic					
Totals	2	3	3	34	42
Percent	4.76	7.14	7.14	80.95	100 00
Post-Archaic					
Totals	17	8	11	191	227
Percent	7.49	3.52	4.85	84.14	100.00
Surface-Collections					
Totals	14	13	6	247	280
Percent	5.00	4.64	2.14	88.21	100.00

In an effort to determine to what degree Archaic and post-Archaic populations practiced scavenging behavior, it was necessary to turn to the excavated assemblages. Table 46 provides data on the number of bifaces in these assemblages that were identified as having been reused or recycled from older bifaces. Although the absolute frequencies are quite different, the percentages are very similar. When the percentages of reused and recycled bifaces are combined, approximately 12 percent of both assemblages were identified as exhibiting evidence of scavenging behavior. Just over 7 percent of the Archaic assemblage and about 3.5 percent of the post-Archaic assemblage were identified as "possibly" reused. Table 46 also shows the numbers of scavenged and "possibly" scavenged bifaces in the surface-collected assemblages for comparison. The proportions are very similar to those from the excavated assemblages.

A chi-square test of independence was computed using a three-way contingency table that combined the reused and recycled categories for both assemblages of excavated bifaces. This still resulted in an expected value of less than 5 for the "possibly" reused Archaic bifaces. Therefore, this category was combined with the reused and recycled categories and the chi-square test was repeated.

The result indicates no significant difference between these two composite assemblages (X^2 obs = .263, *df* = 1, *p* = .608).

Since bifacial implements were curated, and therefore transported and discarded at locations other than where they were first scavenged and/or refurbished, the use of complete or nearly complete hafted bifaces to monitor scavenging at a limit number of sites may not accurately reflect the true extent of this form of lithic procurement. Consequently, an independent test of the scavenging hypothesis was sought. Since the reuse of scavenged bifaces would have focused on previously discarded, broken biface implements, the ratio of broken to complete bifaces should be low in comparison to areas where lithic resources are abundant. Furthermore, among the broken bifacial implements that are present, the occurrence of small and/or highly fragmented pieces should be high in comparison to larger fragments that could have been reused or recycled (Odell 1989).

Table 47 provides raw data on the condition and size of bifaces in Archaic and post-Archaic assemblages from the study area. For comparison, I also include similar data from several sites in Hillsborough and Pinellas counties where chert outcrops are abundant. Table 48 provides summary data for composite Archaic and post-Archaic assemblages separated by region as well as the calculated ratios of broken to complete bifaces (B:C). As the data in these tables show, the B:C ratio for the composite Archaic assemblage from excavated sites in the study area is slightly higher than the B:C ratio for the composite post-Archaic assemblage (Table 48); however, this difference is not statistically significant (X^2 obs = .112, *df* = 1, *p* = .738). Moreover, a series of assemblage-by-assemblage chi-square tests indicate that there is little difference in these ratios when assemblages from the study area are compared to assemblages from contemporaneous Archaic and post-Archaic components in Hillsborough and Pinellas counties (Table 49). The only assemblage that proved to be significantly different is the composite Pineland and Fort Center assemblage. Both of these sites had B:C ratios that approach 1, and their composite ratio is 1:21 (Table 48). The chi-square tests indicate that this composite assem-

Table 47. Condition and size data for complete and broken bifaces from Archaic and post-Archaic assemblages.

Site	Condition		Size[a]		References
	B	C[b]	S[c]	L	
Archaic Assemblages					
8HG18	1	0	1	0	This study
8HG34	0	1			This study
8HG51	5	3	5		This study
8HG678	6	1	3	3	This study
8HG767	2	2	1	1	This study
8HI452	107	33			Estabrook and Newman 1984
8HI473[d]	22	12			Chance 1982; Chance and Misner 1984
8HI476A[e]	81	20			Chance 1983b
8HI557	31	19			Austin and Ste. Claire 1982
8HI5446	38	20	15	23	Meadows 1995
8HR68	3	1	3	0	This study
8HR71	3	1	3	0	This study
8HR92	12	1	3	9	This study
Wells	3	0	2	1	This study
Post-Archaic Assemblages					
8GL13	69	56	43	26	This study
8HG18	4	0	4	0	This study
8HG20	5	0	4	1	This study
8HG27	5	0	4	1	This study
8HG665	3	1	2	1	This study
8HG675	0	4	0	0	This study
8HG678	8	4	6	2	This study
8HI471	19	4			Austin 1982, 1983

Table 47 (Continued).

Site	Condition		Size[a]		References
	B	C[b]	S[c]	L	
8HI515[f]	10	9	4	6	Archaeological Consultants, Inc./Janus Research 1994
8HI556	44	6			Austin and Ste. Claire 1982
8HI558[g]	9	4			Estabrook and Newman 1984
8HR44	4	1	3	1	Bellomo 1993; This study
8HR48	9	4	7	2	Bellomo 1993; This study
8LL33, 36, 37	13	12	7	6	Austin 1995a
8PI894B	11	3			Austin and Piper 1985; Austin and Estabrook 1991
8PI1753	12	9	4	8	Austin 1995b; This study
8PO1685	3	0	2	1	This study

[a] Includes biface fragments only.

[b] This category contains intact specimens as well as nearly complete implements that have small distal, stem, or blade-corner fractures that require only minor refurbishing to render them usable. Hafted bifaces with haft-snap fractures that are otherwise intact also are included.

[c] "Small" is defined as all fragments that measure less than 22 x 19 mm in maximum dimensions.

[d] Includes only hafted bifaces from two subareas of the site.

[e] The condition of 16 bifaces could not be determined.

[f] No measurements given for 11 biface fragments.

[g] The condition of 15 bifaces could not be determined.

blage is significantly different from all of the other assemblages (Table 49). The Yat Kitischee site (8PI1753) also possesses a very low B:C ratio of 1.5, but it was included with other sites from Hillsborough and Pinellas counties. If the Yat Kitischee data are removed, the B:C ratio for this composite assemblage increases to 3.81 (84:22).

These results indicate that with a few exceptions, there is very little geographic or temporal difference in terms of the ratio of broken to complete bifaces. More importantly, differential access to

Table 48. Summary condition and size data and ratios for composite Archaic and post-Archaic assemblages

Assemblages	Condition			Size[a]		
	B	C[b]	B:C Ratio[c]	S[d]	L	S:L Ratio[e]
Archaic, Kissimmee & Peace River Regions	32	10	3.20	19	13	1.46
Post-Archaic, Kissimmee & Peace River Regions	41	15	2.73	32	9	3.56
8LL33, 36, 37 & 8GL13	82	68	1.21	50	32	1.56
Archaic, Hillsborough & Pinellas counties	297	105	2.83	17	24	.71[f]
Post-Archaic, Hillsborough & Pinellas counties	96	31	3.10	8	16	.53[g]

[a] Includes biface fragments only.
[b] This category contains intact specimens as well as nearly complete implements that have small distal, stem, or blade-corner fractures that require only minor refurbishing to render them usable. Hafted bifaces with haft-snap fractures that are otherwise intact are also included.
[c] Ratio of broken to complete bifaces.
[d] "Small" is defined as all fragments that measure less than 22 x 19 mm in maximum dimensions.
[e] Ratio of small to large biface fragments.
[f] Size data come from two sites, 8H15446 and Wells site. See Table 47.
[g] Size data come from two sites, 8HI515 and 8P11753. See Table 47.

raw materials does not seem to be a factor influencing biface discard. Instead, the data suggest that the intensity and duration of site occupation may be more important. Three of the sites with the lowest B:C ratios, and hence the greatest frequencies of complete or nearly complete bifaces, are habitation sites that were occupied permanently or at least seasonally. Two processes may have been at work to create these low B:C ratios. Habitation sites tend to be a focus of tool maintenance activities, and complete bifacial implements may have been discarded there before they reached total exhaustion in order to reduce the risk of failure during use on logistical trips away from the residential base (Kuhn 1989). Interestingly, post-Archaic habitation sites along the Kissimmee River have fairly high B:C ratios indicating either that complete bifaces were discarded elsewhere on site, or they were transported and

Table 49. Results of pair-wise chi-square tests of independence comparing the frequencies of broken and complete bifaces among Archaic and post-Archaic assemblages. Bold entries indicate a significant difference ($p \leq .05$).

Assemblages	K/PR Arch	K/PR PArch	H/P Arch	H/P PArch	8LL33,36,37 & 8GL13
Kissimmee/Peace River Archaic	---	X^2obs=.112 *df* = 1 *p* = .738	X^2obs=.106 *df* = 1 *p* = .745	X^2obs=0 *df* = 1 *p* = 1.000	**X^2obs = 6.302** ***df* = 1** ***p* = .012**
Kissimmee/Peace River Post-Archaic		---	X^2obs=.011 *df* = 1 *p* = .915	X^2obs=.117 *df* = 1 *p* = .733	**X^2obs = 5.831** ***df* = 1** ***p* = .016**
Hillsborough/ Pinellas Archaic			---	X^2obs=.148 *df* = 1 *p* = .701	**X^2obs = 18.742** ***df* = 1** ***p* = < .0001**
Hillsborough/ Pinellas Post-Archaic				---	**X^2obs = 13.854** ***df* = 1** ***p* = .0002**
8LL33, 36, 37 & 8GL13					---

discarded at off-site locations. Unfortunately, none of these sites has received the type of large-scale excavation that has occurred at Pineland, Fort Center, or Yat Kitischee, so it is not possible at present to evaluate objectively which of these scenarios is correct. A second possibility is the potential limited use of bifaces acquired through exchange in utilitarian tasks that result in a high degree of breakage because of their high prestige value. This certainly seems to have been a factor at Fort Center, where several complete hafted bifaces were recovered from contexts believed to be associated with ceremonial and special crafting activities.

Turning to the data on the sizes of biface fragments in Archaic and post-Archaic assemblages, we see a much different pattern. The ratios of small to large biface fragments (S:L) are much higher in the Archaic assemblages when compared to the composite post-Archaic assemblages (Table 48).

"Small" is defined here as any biface fragment that measures less than 22 mm long by 19 mm wide. These size parameters are based on the smallest length and width measurements of hafted bifaces that are believed to have been manufactured from distal or proximal biface fragments. Fort Center, Pineland, and Yat Kitischee again are anomalies since they possess S:L ratios that are quite low. This seems to suggest that the low B:C ratios at these sites are a function of discard practices rather than differential scavenging However, the S:L ratios at these sites are somewhat misleading because several of the larger fragments exhibit extensive damage as a result of uncontrolled exposure to heat. This evidence includes crazing lines, pot-lid and crenated fractures, and frosting. The structural weaknesses caused by rapid over-heating would have rendered these fragments unsuitable for withstanding impact associated with efforts to rework them into functional tools (although two of these biface fragments from Pineland were recycled for use as expedient tools). If the heat-damaged artifacts are combined with those in the "small" category, the ratio between usable and unusable fragments approaches that of the composite post-Archaic assemblage from sites in the Peace River and Kissimmee regions (65:17, or 3.82).

Comparing these ratios to those from sites in chert-rich areas is difficult because size data are not provided consistently for all fragments in many published reports. Only one report on an Archaic period site (8HI5446) provided such data for all fragments analyzed (Meadows 1995:Appendix A). Another provided partial data for 8HI515, a post-Archaic site (Archaeological Consultants, Inc./Janus Research 1994). These data are presented in Tables 47 and 48. The size data from the Wells site and Yat Kitischee were added to those from 8HI5446 and 8HI515 to compute S:L ratios for Archaic and post-Archaic sites from a chert-rich area in Table 48. Both the Archaic and post-Archaic assemblages have S:L ratios of less than 1 indicating that the discard of large bifacial fragments outnumbered small fragments at these sites by almost a 2 to 1 margin, exactly the reverse of sites within the study area While it is not possible to argue that these three sites represent an adequate sample from a chert-rich

Table 50. Results of pair-wise chi-square tests of independence comparing the frequencies of small and large biface fragments among Archaic and post-Archaic assemblages. Bold entries indicate a significant difference ($p \leq .05$).

Assem-blages	K/PR Arch	K/PR PArch	H/P Arch	H/P PArch	8LL33, 36,37 & 8GL13[a]	8LL33, 36,37 & 8GL13[b]
K/PR Archaic	---	X^2obs = 2.977 df = 1 p = .085	X^2obs = 2.307 df = 1 p = .129	X^2obs = 3.725 df = 1 p =.054	X^2obs = .025 df = 1 p = .875	**X^2obs =** **4.698** **df = 1** **p = .030**
K/PR Post-Archaic		---	**X^2obs =** **11.41** **df = 1** **p = .0007**	**X^2obs =** **12.787** **df = 1** **p = .0003**	X^2obs = 3.585 df = 1 p = .058	X^2obs = .024 df = 1 p = .876
H/P Archaic			---	X^2obs = .423 df = 1 p = .516	**X^2obs =** **4.196** **df = 1** **p = .041**	**X^2obs =** **17.579** **df = 1** **p= < .0001**
H/P Post-Archaic				---	**X^2obs =** **5.725** **df = 1** **p = .017**	**X^2obs =** **18.272** **df = 1** **p = < .0001**
8LL33, 36, 37 & 8GL13[a]					---	**X^2obs =** **6.548** **df = 1** **p = .011**
8LL33, 36, 37 & 8GL13[b]						---

[a] Based on unadjusted totals in Table 48.

[b] Based on totals adjusted for thermally fractured bifaces

area, the comparison does support, albeit tentatively, the hypothesis that scavenging of larger biface fragments was more prevalent in chert-poor areas

Assemblage-by-assemblage chi-square tests indicate that post-Archaic assemblages in the study area are significantly different from Archaic and post-Archaic assemblages in Hillsborough and Pinellas counties in terms of the frequency distributions of small versus large biface fragments (Table 50).

While the Archaic assemblage from the study area is not significantly different from any except the adjusted Pineland and Fort Center assemblage, 2 of the 4 *p* values are less than .10 indicating that the probability is less than 10 percent that the differences have occurred by chance. It is important to realize that the chi-square statistic is sensitive to sample size (Blalock 1972:285-286; Shennan 1990:77-78). Since the relationship is a proportional one, it is easier to obtain a statistically significant result with a large sample but difficult to obtain one with a small sample unless the differences are exceptionally large. Thus, the failure to reject the null hypothesis of no difference should not be interpreted as meaning that there are no differences between these assemblages, but only that the differences are not statistically significant given the parameters of the test. The fact that the S:L ratios of the post-Archaic assemblage is nearly 2.5 times as great as the Archaic S:L ratio indicates that the difference is substantial and may well have interpretive significance. The same can be said for the differences between the study area Archaic assemblage and the Archaic and post-Archaic assemblages from Hillsborough and Pinellas counties.

Summary. The data presented here indicate that scavenging of bifacial implements occurred within the study area during both the Archaic and post-Archaic periods. Although comparative data from chert-rich areas are limited, they are suggestive of an increased tendency to practice scavenging as a risk-reduction strategy in chert-poor areas. Differences in the ratios of broken and unbroken bifaces between assemblages within the study area appear to be due to conditions of site use; that is, the tendency to perform tool maintenance tasks at habitation sites and discard tools with high residual utility to decrease the risk of failure during task performance. The restricted use of bifaces obtained through exchange in ceremonial or special crafting tasks may also have been a factor at some sites, such as Fort Center.

Storage

The last risk-reduction strategy to be considered is storage, which can consist of either the stockpiling of materials acquired via direct or indirect procurement or the caching of raw materials, blanks, preforms, or finished implements so that they can be available for use at a future time. The evidence for storage in the study area is not overwhelming, due in part to the limited extent of the excavations conducted at most sites. The most convincing evidence comes from Fort Center's Mound A where a "cache" of water-tumbled chert cobbles was recovered (Steinen 1982:82). The FLMNH catalog for this particular feature (FLMNH A16439, FAU A1774) indicates that a total of 66 cobbles and associated debitage came from an area approximately 30 cm (1 foot) in diameter and at a depth of about 30 cm (1 foot). Analysis of these artifacts indicates that there are 55 tested cobbles, 9 cobble cores, 2 cobble fragments, and 15 waste flakes associated with this feature. Two of these cobbles (one tested cobble and one cobble fragment) appear to have battering wear on them and may have been used as hammerstones.

Steinen (1971:35, 1982:82) reports that the cache contained 52 "nodules" of which 31 were broken or chipped to expose their interiors. The discrepancy in the numbers of cobbles from this feature is unexplained; however, the size and depth information in the FLMNH catalog match those given by Steinen, and the number of waste flakes associated with this provenience matches the number Steinen reports was found with the cache of cobbles. Several of the flakes can be refitted to the cobble cores, verifying that these flakes were produced through the reduction of the cobbles in the feature.

The unmodified and tested cobbles are ovate to slightly irregular in shape but fairly uniform in size (Figure 55). Mean length is 48.68 mm, mean width is 42.58 mm, and mean thickness is 23.83 mm. The largest cobble measures 64.05 x 50.2 x 44 8 mm and the smallest measures 31.2 x 31.35 x 18.85 mm. As discussed above, these cobbles are believed to have come from either the Hillsborough River Quarry Cluster or, less likely, from the Peace River Quarry Cluster.

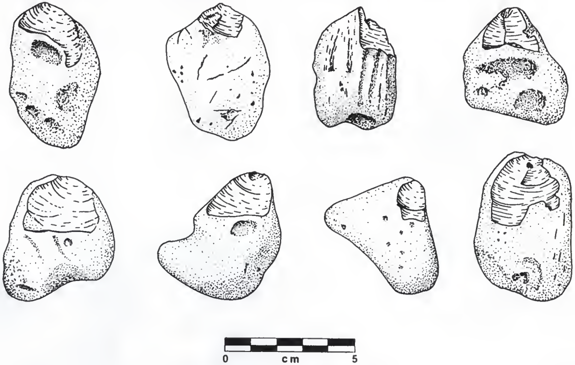


Figure 55. Chert cobbles from Fort Center's Mound A

In addition to the cobbles in the feature, an additional 17 cobbles, cobble cores, and hammerstones, 243 waste flakes, 3 bifaces, and 11 microliths and flake tools were recovered from Mound A. This distinctive-looking material was minimally represented elsewhere on the site with only 2 cores, 2 hammerstones, 12 waste flakes, and 2 flake tools found in other locations. One of these cores and a hammerstone were recovered from the nearby charnel pond. In his original analysis of the Fort Center lithic artifacts, Steinen (1982) suggested that the cobbles at Mound A were used to produce the hafted bifaces found there. He describes the majority of the debitage at Mound A as gray, gray/white, and brown in color, which accurately describes much of the debitage resulting from reduction of the cobbles; however, he also asserts that this material is similar to that from which most of the Mound A bifaces were made (Steinen 1971:35, 1982:82), implying that the debitage was related to the production of the Mound A bifaces.

My analysis of the Fort Center artifacts indicates that only three bifacial tools were made from the cobble material, and one of these is a roughly worked, bifacial core tool. All three came from Mound A; however, the remaining 37 bifacial implements from Mound A were manufactured out of non-cobble, Tampa Limestone cherts from the Hillsborough River Quarry Cluster (11, or 27.5 percent) followed by Ocala Limestone cherts (8, or 20 percent; four Lower Suwannee/Lake Panasoffkee Quarry Cluster and four Ocala Quarry Cluster), silicified coral (4, or 10 percent), Withlacoochee Quarry Cluster cherts (2, or 5 percent), and Peace River chert (1, or 2.5 percent). Raw-material provenience could not be made for 11 bifaces (27.5 percent); however, four of these were classified as possibly being made from Lower Suwannee/Lake Panasoffkee Quarry Cluster chert based on similar rock fabric and color. None of the 11 "unidentified" chert types resembled the cobble chert.

While my provenience analysis does not support Steinen's hypothesis that the cobbles were used to manufacture the bifaces found at Mound A, or anywhere else at Fort Center, it does indicate that the cobbles were used to make flake tools and microliths, most of which were recovered from Mound

A. Furthermore, use-wear analysis indicates these flake tools and microliths were used primarily in wood, bone, and shell-working, tasks that also were associated with many of the hafted bifaces recovered from this feature.

Yat Kitischee also contains a comparatively large number of unmodified chert "rods" and cores made from these rod-shaped pieces of chert (Figure 56). As discussed in Chapter 7, these small rod-shaped pieces of siliceous stone are believed to have formed in solution channels within the limestone deposits of the upper Hawthorn. In addition to the eight cores made from this material, an additional 33 unmodified rods were recovered from the site. This material was used exclusively to manufacture small microliths (Appendix B). Broad-scale testing of the site indicates that this material may have been restricted in its spatial distribution since it was recovered only from one location where block excavation was conducted. The material also was restricted temporally to the most recently deposited stratigraphic zone (Austin 1995b).

The third site where caching is indicated is the Driggers #2 site (8HG51) on the north shore of Lake Istokpoga. This small, primarily Archaic period site is characterized by a relatively sparse assemblage of lithic waste flakes and broken bifaces. However, in two locations concentrations of lithic debitage were encountered along with complete and unused hafted bifaces. All of the flakes in these two concentrations are made from the same material: a lustrous, sandy, opal-rich chert derived from the Peace River Quarry Cluster. The three hafted bifaces associated with these flake concentrations are manufactured from chert that is identical to the waste flakes. There is little doubt that the flakes are the by-product of the manufacture of these bifaces.

Careful examination of all three hafted bifaces indicates that at least one, and possibly all three, may have been broken proximal fragments that were transported to the site and reworked into functional implements. All are small in size and one exhibits differential patination on its blade. The absence of use-wear on their lateral margins, and the fact that none display any use-related fractures, suggests that

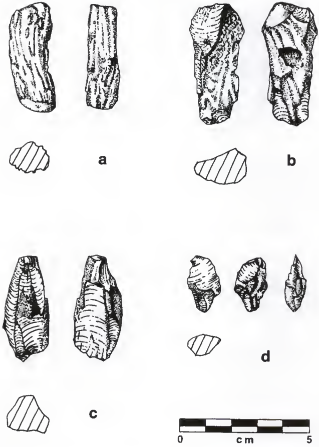


Figure 56. Cores used in the production of microliths at Yat Kitischee. a) unmodified rod-shaped piece of chert; b-c) bipolar cores showing flake removals from opposing ends; d) exhausted bipolar core with tapered, wedge-shaped striking platform.

they were not discarded because they were no longer functionally useful, but were intentionally left at the site to be used at a future date.

Summary. Evidence of caching behavior is limited but present in both Archaic and post-Archaic contexts within the study area. Additional evidence of caching behavior is common in the archaeological record of Florida, with most documented occurrences coming from chert-rich areas of north and west-central Florida (e.g., Alexson 1988; Chance 1983b:209-213; Hardman and Hardman 1994; Tesar and Watson 1993; Watson et al. 1990; see also the review of lithic caches in Tesar and Watson 1993:78-80). Caching or stockpiling of lithic raw materials conforms to what Ingold (1983) has referred to as "practical" storage, which is meant to solve the problem of temporal and spatial discontinuity in the distribution of resources. However, the fact that lithic caches are found in both chert-rich and chert-poor environments indicates that resource distribution alone does not adequately explain such behavior. Storage also facilitates the scheduling of mutually exclusive activities that cannot be performed simultaneously (Ingold 1983:557-558; Jochim 1976:30-31; Torrence 1983). When viewed in this fashion, the concept of storage can be extended to discarded lithic items that are available for future scavenging, reuse, and recycling (cf. Binford 1978:146).

Conclusion

The results of the analyses presented in this chapter indicate that Archaic and post-Archaic peoples both practiced risk-reduction strategies with regard to the procurement of lithic raw materials. However, the nature of these strategies differed. The Archaic period is characterized by a greater reliance on direct acquisition at the source locations of these materials. Some gift exchange may have occurred, although this is hard to document archaeologically with the present data. The best possibility for gift exchange is the hafted bifaces manufactured from Ocala Limestone cherts since the source areas for these raw materials are located farthest from the sites in the study area. The data also indicate that

Archaic peoples were transporting lithic raw materials in a variety of package sizes; in other words, as bifacial preforms, finished bifacial implements, and, to a lesser extent, small cores. Discard rates were generally lower than during the post-Archaic indicating higher rates of curation, less permanent residency at specific sites, or both.

In comparison, post-Archaic peoples appear to have relied to a greater degree on indirect procurement, although direct acquisition of local raw materials, both siliceous and non-siliceous, occurred when and where they were available. Exchange may have occurred in a number of forms including gift, utilitarian, or prestige and this may have contributed to the variability in distance-decay patterns exhibited by the various raw materials.

The data also indicate that bifacial implements were imported to post-Archaic settlements in advanced stages of production; in other words, as finished implements primarily, especially those bifaces made from cherts derived from the Ocala, Lower Suwannee/Lake Panasoffkee, and Withlacoochee quarry clusters. Small cores appear to be another common form of transported materials. The degree to which Archaic and post-Archaic peoples depended on bifaces versus cores is examined in more detail in Chapter 11.

With regard to the practice of diversification, there is evidence that a greater variety of chert resources were exploited during the Archaic This is believed to be related to two factors: 1) a high degree of residential mobility that brought Archaic hunter-gatherers into contact with a wider range of resource types, and 2) the need to exploit more raw-material sources as access to high-quality lithic sources became more restricted. Optimization analysis of thermal alteration suggests that use of this technology, which peaked during the middle Archaic period, is an efficient strategy for reducing procurement risk by enabling a wider range of lower-utility resources to be made available within a technological system that was highly dependent on curated bifaces (see Chapter 11).

Chert-type diversity apparently decreased during the post-Archaic and there was a greater emphasis on locally available raw materials, particularly in the Peace River region, but also at Fort Center, Pineland, and Yat Kitischee. At these last three sites raw materials such as quartz, dolomite, or fossil bone, which were not suitable for extensive use within a chipped-stone industry, were experimented with as replacements for higher-quality cherts. More importantly, however, all three of these sites had access to alternative sources of raw materials such as shell and sharks' teeth which could adequately replace stone for many tasks. Pineland and Yat Kitischee both had direct access because of their coastal locations while Fort Center had access via trade. Thus, while diversification of siliceous raw materials may have decreased during the post-Archaic, in the broader sense, raw-material diversification increased since there was a greater dependence on alternative raw materials.

Both Archaic and post-Archaic peoples scavenged lithic artifacts and either reused or recycled them within their existing technological systems. The data seem to indicate that this was a strategy that was more common in chert-poor areas than in areas where chert was more abundant. However, additional data from chert-rich areas should be gathered before any conclusions can be made with certainty. Nonetheless, the fact that scavenging occurred at Archaic and post-Archaic sites within the study area, indicates that demand for siliceous raw materials remained relatively high, and that scavenging was used to guard against raw-material shortfalls.

Finally, although the data are limited, it appears that both Archaic and post-Archaic peoples practiced different types of caching or stockpiling of lithic materials. Since the occurrence of lithic caches has been documented in chert-rich areas, it appears that the factor that influenced whether this type of strategy was practiced was not tied exclusively to raw-material availability, but instead was related to the scheduling of mutually exclusive activities. Since we might expect time stress to be more acute in sedentary or logistically mobile societies, the fact that lithic caches also occur in situations of high residential mobility suggests that activity scheduling was an important consideration within both types of settlement systems.

In the next chapter I look at the ways in which prehistoric people occupying the study area coped with the costs associated with the procurement of lithic raw materials.

THE ECONOMICS OF LITHIC-RESOURCE USE IN SOUTH-CENTRAL FLORIDA

By

ROBERT JAMES AUSTIN

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THIS TITLE IS BOUND IN TWO PARTS.

THIS IS PT. 2.

CHAPTER 10
STRATEGIES FOR COPING WITH PROCUREMENT COST

As discussed in Chapter 6, the costs associated with procurement in a chert-poor area are associated primarily with the labor and energy that must be invested in traveling to a source location and transporting back potentially bulky raw materials. If the procurement strategy is indirect, then the labor and energy costs are those associated with the acquisition, processing, and transport of materials and goods offered in exchange. In this and the following chapter I examine some of the ways in which prehistoric hunter-gatherers in south Florida developed strategies to cope with these costs. I first look at efforts to minimize labor costs directly by reducing the cost of transport. I then examine strategies for indirectly dealing with procurement costs through economizing, reducing handling costs, and reducing raw-material demand.

Minimization of Transport Costs

All things being equal, as the cost of transport becomes more excessive efforts should be made to increase the portability of lithic raw materials. As discussed in Chapter 6, the primary way to achieve this is to conduct the early stages of tool production at the raw-material source to decrease the amount of excess material that must be transported. Cost minimization can thus be identified archaeologically in three ways: a reduction in core size with distance, a reduction in the size of hafted bifaces with distance, and a reduction in the amount of cortex material with distance.

Core Size

Core-size data were collected from sites in the study collection and these were compared to core-size data in the published literature. Unlike in Chapter 9, for this analysis I confine the "core" category to true cores, core fragments, and hammerstones. The last two were included because they represent potential sources of raw material, particularly in chert-poor areas. Many examples of exhausted cores that were recycled for use in hammering are present in the study collection, as well as hammerstones that were subsequently used as cores. I also have included the unmodified cobbles from Fort Center since these too represent transportable raw materials. The unmodified chert "rods" from Yat Kitischee are not included simply because size measurements were not made on these items during the original analysis. Although bifaces represent a potential source of raw material, they are treated separately and so are not included in the "core" category.

Before continuing, it is necessary to discuss several problems that were encountered in using published data for comparison with the research data. First, nearly all of the published reports fail to identify specific raw materials. At best, some simply distinguish between silica-replaced limestone (chert) or silicified coral. The obvious disadvantage is that there is no way to know if the artifact(s) came from a nearby or distant chert source. In an attempt to limit the potential for error, I restricted my literature search to those sites that are located in or near a chert quarry cluster. The assumption is that those sites located within a known quarry cluster would most likely have exploited the chert contained in that cluster. Thus, sites in Hillsborough County would most likely be dominated by cherts from the Hillsborough River Quarry Cluster. This assumption appears to be valid based on recent studies that have incorporated analyses of raw-material provenience (e.g., Archaeological Consultants, Inc./Janus Research 1994; Austin et al. 1992; Deming et al. 1984a; Estabrook 1990; Estabrook and Williams 1992). Consequently, distances were calculated to the nearest documented quarry or chert exposure. For those sites where raw-material types have been identified, including the sites analyzed specifically for this study, separate distance measures were calculated for each identified raw-material type in an assemblage. These are indicated in Table 51 by letters in parentheses following site numbers. The letters represent specific quarry clusters or chert types which are identified in a key at the bottom of the table.

A second problem is that core-size data are not recorded consistently in many reports. Some include size measurements (length, width, and thickness), some report only weight, while others report both. In order to use the largest number of sites possible, it was necessary to generate distance-decay plots for both size and weight.

To arrive at a standardized measure that accurately reflects the total size of a core or assemblage of cores, a size index was derived by multiplying Length x Width x Thickness and dividing the result by 1000. Some of the published data used in this analysis were presented in their original forms as means. In two cases (8HI473 and 8HI476A), mean size data were presented by subarea. In order to arrive at mean size indices for these sites, it was necessary to calculate a weighted mean size index for each subarea, add the weighted means together, and then divide by the total number of cores at the site (see Blalock 1972:71-72 for a discussion of the procedure for obtaining weighted averages). Table 51 provides the raw data on core size and weight for all of the sites used in this analysis.

Figure 57a shows the distribution of core size by distance for Archaic period sites and components. As this figure shows there is a curvilinear decrease in core size as distance to chert source locations increases. Furthermore, this drop-off occurs quite rapidly, within about 5-10 km of a source area. After this, core size begins to level off. There is one exception to this pattern: a single core of Ocala Quarry Cluster chert from the Driggers #2 site (8HG51). This core has a size index of 188.4, much larger than would be expected considering its distance from the nearest source of this chert type (156.1 km), although still significantly smaller than the average size of cores located at quarry sites

Table 51 Core size and weight data.

Site[a]	Dist (km)[b]	N[c]	Core Size[d]	Hmstn Size[d]	Combined Size[e]	Core Weight[f]	Hmstn Weight[f]	Combined Weight[g]	Reference
Archaic Assemblages									
8AL172	.25	1					720.0	720.0	Hemmings and Kohler 1974
8HI374	7.2	1		142.80	142.80				Swindell 1977
8HI452	5.6	1		139.10	139.10		127.6	127.6	Estabrook and Newman 1984
8HI473	0	75	347.20		347.20	306.60		306.6	Chance and Misner 1984
8HI476A	4.8	19				45.10		45.1	Chance 1983a
8HI2187	3.2	1		81.40	81.40		68.1	68.1	Williams and Estabrook 1988
8HI3281	.5	2					96.0	96.0	Williams and Estabrook 1987
8HI5446	8	14	60.10		60.10	49.90		49.9	Meadows 1995
8HG51(O)	156.1	1	188.39		188.39	207.30		207.3	This study
8HR68(CHC)	56.3	1	33.65		33.65	36.50		36.5	This study
8HR68(HR)	29.8	1	21.31		21.31	20.20		20.2	This study
8HR71(C)	53.1	1	5.86		5.86	5.40		5.4	This study

Table 51 (Continued).

Site[a]	Dist. (km)[b]	N[c]	Core Size[d]	Hmstn Size[d]	Combined Size[e]	Core Weight[f]	Hmstn Weight[f]	Combined Weight[g]	Reference
8HR92(HR)	38 6	2	33.76		33.76	35.70		35.7	This study
8OS123(W)	39.4	1	67.44		67.44	44.40		44.4	Estabrook 1991
8OS123(HR)	74 8	1	14.37		14.37	13 40		13.4	Estabrook 1991
8PI66	.5	95/10	434 40	288.80	420.50				Wolf 1975
Post-Archaic Assemblages									
8GL13(CHC)	167 4	1	175.90		175.90	161.60		161.60	This study
8GL13(COB)	88.5	77/6	42.83	71.41	44.76	39.69	95.66	43.52	This study
8GL13(HR)	151.3	2/1	5.83	85.03	32.23	8.46	122.20	46.37	This study
8GL13(UID)[h]	88.5	1		35.24	35.24		54.60	54.60	This study
8GL13(QZ)	1	4	23.11		23.11	30.63		30.63	This study
8GL13(LS/LP)	230.1	1	2.39		2.39	3.10		3.10	This study
8HG18(BB)	132	1	22.40		22.4	22.10		22.10	This study
8HG27(UID)	64.4	1	26.40		26.4	31.90		31.90	This study
8HI515	6.4	2	12.40		12.40	11.75		11.75	Archaeological Consultants, Inc./Janus Research 1994

Table 51 (Continued).

Site[a]	Dist (km)[b]	N[c]	Core Size[d]	Hmstn Size[d]	Combined Size[e]	Core Weight[f]	Hmstn Weight[f]	Combined Weight[g]	Reference
8HI558	5.6	3/4				71.10	132.51	106.20	Estabrook and Newman 1984
8HR44(PR)	14.5	1	76.80		76.80	63.00		63.00	This study
8HR48(HR)	40.2	1	4.90		4.9	6.50		6.50	This study
8HR48(PR)	13.7	1	8.60		8.6	7.60		7.60	This study
8LL33,36, 37 (CHC)[i]	157.7	1	47.27		47.27	57.95		57.95	Austin 1995a; This study
8LL33,36,37 (DO)	1	1		113.64	113.64		111.40	111.40	Austin 1995a; This study
8LL33,36,37 (HR)	115.1	1	6.70		6.70	7.40		7.40	Austin 1995a; This study
8LL33,36, 37 (T3/T4)	142.4	3/2	140.50	105.80	126.61	147.60	119.90	136.50	Austin 1995a; This study
8PI1753(C)	21.7	1		30.00	30.00		27.60	27.60	This study
8PI1753(CHC)	35.4	1/3	9.70	190.70	145.50	12.10	181.60	139.30	This study
8PI1753(SC)	19.3	1	68.50		68.50	66.00		66.00	This study
8PI1753(TCP)	6.4	8	7.80		7.80	6.70		6.70	This study
8PI1753(T4/BB)	11.3	1/1	27.40	200.70	114.00	27.30	191.90	109.60	This study

Table 51 (Continued).

Site[a]	Dist. (km)[b]	N[c]	Core Size[d]	Hmstn Size[d]	Combined Size[e]	Core Weight[f]	Hmstn Weight[f]	Combined Weight[g]	Reference
8PI1753(W)	59.5	1		93.10	93.10		109.50	109.50	This study

[a] Letters in parentheses refer to chert quarry clusters or types: BB = Bay Bottom chert (Type 5), Hillsborough River Quarry Cluster; C = Caladesi Quarry Cluster, CHC = Cow House Creek chert, Hillsborough River Quarry Cluster; COB = cobbles, Tampa Limestone chert; DO = dolomite; HR = Hillsborough River Quarry Cluster; LS/LP= Lower Suwannee/Lake Panasoffkee Quarry Cluster; O= Ocala Quarry Cluster; PR = Peace River Quarry Cluster, QZ = quartz pebbles; SC = silicified coral; T3 = Type 3 chert, Hillsborough River Quarry Cluster; T4 = Type 4 chert, Hillsborough River Quarry Cluster, TCP = Turtlecrawl Point Quarry Cluster; UID = Unidentified, W = Withlacoochee River Quarry Cluster

[b] Distances are straight-line measurements between a site and the nearest chert exposure.

[c] Numbers separated by a slash indicate number of cores/hammerstones.

[d] Mean size index. Individual size indices were calculated by multiplying length x width x thickness and dividing the result by 1000.

[e] Mean size index for combined cores and hammerstones.

[f] Mean weight in grams.

[g] Mean weight in grams for combined cores and hammerstones.

[h] Source of raw material not identified. Distance was calculated to nearest chert source.

[i] Utilized core fragment. Not included in core totals for this site in Appendix A.

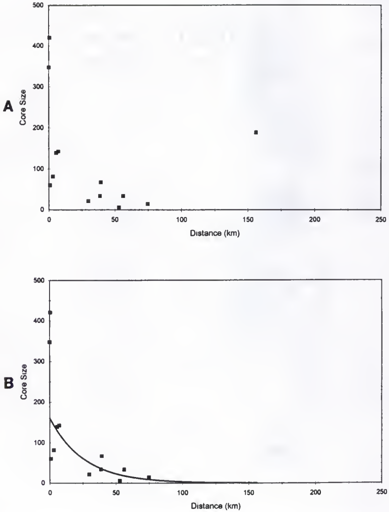


Figure 57 Relationship between core size and distance to chert resources for a) Archaic period sites and b) with 8HG51 removed.

(e.g.,compare with the mean size indices for 8HI473 and 8PI66 in Table 51). This single core appears to represent an "outlier" from the general distributional trend, and so was dropped from the analysis.

When this anomalous data point is removed, the resulting distribution is smoother and clearly exponential in form (Figure 57b) with an r value of -.806 and $r^2 = .649$ ($p = .073$). A similar pattern is observed when core weight is examined (Figure 58a). Again, the core from 8HG51 stands out as anomalous and so was dropped from the second calculation. The new distribution (Figure 58b) produced a fairly high r value of -.739, but only about half of the variation displayed by the weight data is explained by the independent variable, distance ($r^2 = .546$, $p = .619$). While neither the size-distance or weight-distance relationships for Archaic period cores are statistically significant, the general pattern is one of a rapid decrease in core size with distance.

In comparison, cores recovered from post-Archaic sites exhibit more variability in both core size (Figure 59) and core weight (Figure 60). The best-fit regression lines are hyperbolic in form and the correlation coefficients for these distributions are low (size: $r = .351$, $r^2 = .123$, $p = 535$; weight: $r = .291$, $r^2 = .085$, $p = .539$) suggesting that there is very little correlation between core size and distance to chert resources. However, examination of these figures indicates that one core from Fort Center (8GL13[LS/LP]) with a very low size index of 2.39 could be affecting the right side of the graph. When this data point is removed, curvilinear increases in core size (exponential) and weight (hyperbolic) are indicated (Figures 61 and 62); however, the correlations are very low and not significant (size: $r = .177$, $r^2 = .031$, $p = .535$; weight: $r = -.193$, $r^2 = .037$, $p = .560$).

Examination of the data in Table 51 indicates that hammerstones tend to be consistently larger than cores. In an effort to determine if the two artifact classes exhibited different size-distance relationships, the two were plotted separately. The small core from 8GL13 was not included in these plots. Figure 63a, which plots core size minus hammerstones versus distance, indicates a linear and slightly positive relationship ($r = .321$, $r^2 = .103$, $p = .207$). A similar linear pattern is observed when

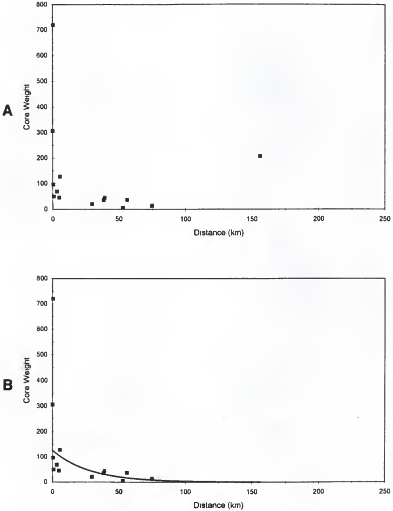


Figure 58. Relationship between core weight and distance to chert resources for a) Archaic period sites and b) with 8HG51 removed.

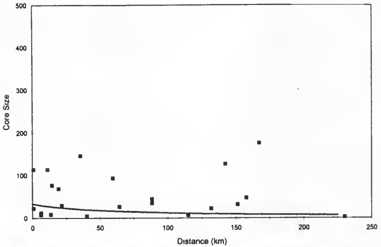


Figure 59. Relationship between core size and distance to chert resources for post-Archaic period sites.

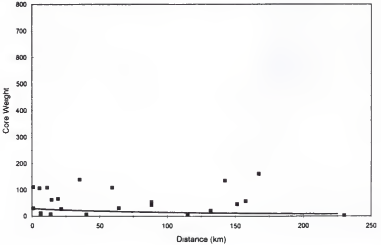


Figure 60. Relationship between core weight and distance to chert resources for post-Archaic period sites.

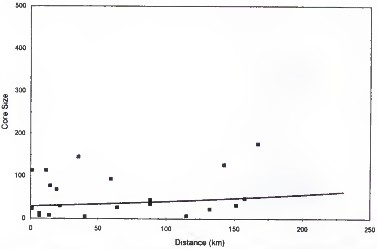


Figure 61. Relationship between core size and distance to chert resources for post Archaic sites, one outlying data point removed.

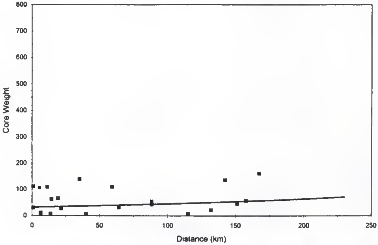


Figure 62. Relationship between core weight and distance to chert resources for post-Archaic sites, one outlying data point removed.

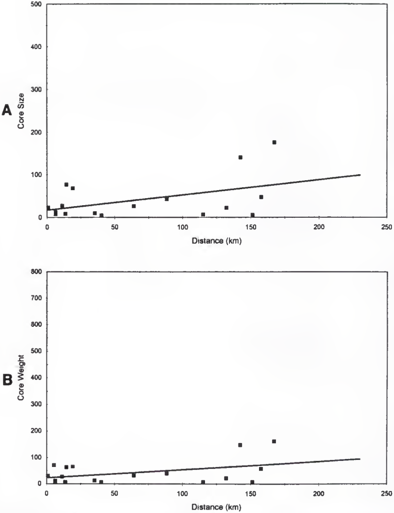


Figure 63. Relationship between core size and distance to chert resources for post-Archaic period sites: a) core size minus hammerstones; b) core weight minus hammerstones. One outlying data point has been removed.

core weight is plotted versus distance (Figure 63b, $r = .427$, $r^2 = .182$, $p = .075$). Interestingly, when post-Archaic hammerstones are plotted (Figure 64), slight reductions in both size and weight are evident as distance increases (size: $r = -.340$, $r^2 = .116$, $p = .627$; weight: $r = -.171$, $r^2 = .029$, $p = .640$).

Summary. Although none of the correlations proved to be statistically significant at an alpha level of $\leq .05$, the general patterns exhibited by these data indicate clear differences between Archaic and post-Archaic uses of cores. The Archaic data display a rapid fall-off in core size as distance to chert sources increases while the post-Archaic data display a possible increase in size with distance to raw-material source. Even if the most conservative interpretation is taken, that is, using all of the data without removing outlying data points, the post-Archaic data differ from the Archaic data in the amount of variability exhibited in core sizes at different distances. However, it must be stressed that no data for post-Archaic quarry sites could be uncovered in the literature. It is not clear whether this lack of information is a true reflection of post-Archaic quarrying behavior. Although Purdy (1981:47, 54), has suggested that quarrying activity was greatly reduced following the Archaic period as post-Archaic peoples reduced their dependence on stone and increased their dependence on scavenged stone tools and alternative raw materials such as marine shell, evidence from the Rock Hammock site (8HI556) in Hillsborough County indicates that quarrying activity continued into at least the early Manasota period and perhaps later (Austin and Ste. Claire 1982; Ste. Claire 1996a).

The absence of data on core-size from post-Archaic quarry sites has undoubtedly influenced the size-distance relationships presented here. If cores from post-Archaic quarry sites were included in the analysis, we could anticipate that these would be substantially larger than those found at sites located where chert sources are not locally available. Thus, the relationship between distance and either size or weight would probably approach an exponential form similar to that for the Archaic period cores. But even if such a relationship is assumed, the sizes and weights of cores in the post-Archaic assemblages do seem to exhibit more variability in size.

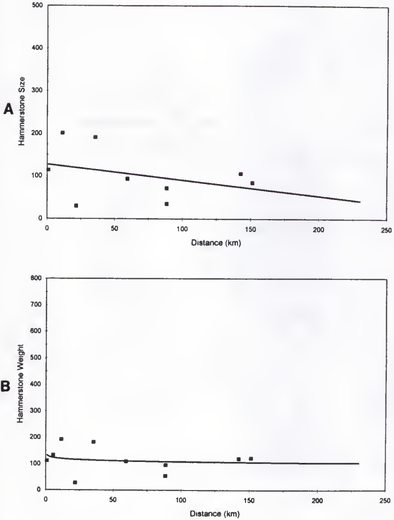


Figure 64. Relationship between distance to chert resources and a) hammerstone size and b) hammerstone weight.

Tool Size

A second indicator of the attempt to minimize transport costs is the sizes of tools that are transported. The most common tool form in both the Archaic and post-Archaic assemblages is the hafted biface (see Appendices A and B). As with the cores, a standardized measure of size (Length x Width x Thickness divided by 100) was used to compare different hafted-biface types. Only complete or nearly complete hafted bifaces were used in this analysis. Nearly complete bifaces have small portions of their distal ends, stems, or blade corners broken, but the fractures are not large enough to bias overall size measurements. The raw data for individual specimens in the study collection are presented in Appendix E.

Because the size ranges of different biface types vary, mean size indices were obtained for the various types of Archaic and post-Archaic hafted bifaces present in the study collection. These were compared to mean size indices calculated for corresponding hafted-biface types from sites located in chert-rich areas of west-central and north-central Florida. These data represent the control sample. Comparative size data were obtained from the available literature and from the specimen dimensions presented in Robinson (1979), and these were converted to size indices using the formula described above. In addition to size data for individual specimens, Robinson also presents locational information (site name and county). All of the type examples presented in his study come from sites located in portions of the state where chert exposures are common, so the dimensional data were felt to be acceptable for comparison with the study collection. Table 52 provides the mean size indices for all the hafted-biface types used in this analysis.

As the data in Table 52 indicate, of the 23 types in the study collection for which there are comparable data from chert-rich areas, 17 (73.91 percent) have size indices that are smaller than the control sample. These include nine of the ten biface types that are typically assigned to the Archaic period (Bolen, Culbreath, Greenbriar, Hillsborough, Levy, Marion, Newnan, Putnam, and Sumter) and

Table 52. Size-index data for hafted bifaces.

Hafted-Biface Type	Control Data[a]				Study Collection[b]				p^c
	N	Mean	SD	CV	N	Mean	SD	CV	
Archaic Types									
Bolen	36	100.20	33.03	.33	3	45.10	29.31	.65	**.008**
Culbreath	31	245.42	114.35	.47	3	148.91	58.30	.39	.082
Greenbriar	19	100.45	27.05	.27	1	51.58	0.00	.00	d
Hardee	3	120.42	57.31	.48	5	147.08	72.86	.50	.286
Hillsborough	16	135.10	36.06	.27	2	88.58	45.66	.52	.055
Levy	48	239.13	190.38	.80	10	145.85	64.54	44	.067
Marion	42	294.04	152.75	.52	31	150.41	80.37	.53	**<.0001**[e]
Newnan	32	193.66	125.35	.65	14	161.31	91.30	.57	.195
Putnam	25	218.45	106.60	.49	10	141.22	63.76	.45	**.011**
Sumter	7	219.27	34.32	.16	3	218.44	75.63	.35	.491
FAS[f]					5	112.40	80.72	.72	g
Diminutive FAS	3	69.18	2.92	.04	19	79.79	56.31	.71	423
Post-Archaic Types									
Bradford	12	168.73	77.59	.46	3	161.24	168.23	1.04	.473[e]
Broward	3	223.18	81.91	.37	4	180.61	45.76	.25	.208
Columbia	2	203.58	25.84	.13	6	157.52	37.91	.24	.085

Table 52 (Continued).

Hafted-Biface Type	Control Data[a]				Study Collection[b]				p^c
	N	Mean	SD	CV	N	Mean	SD	CV	
Copena	4	125.44	40.07	.32	1	49.19	0.00	.00	d
Duval	10	76.34	20.57	.27	3	119.88	51.21	.43	.138
Hernando	41	83.61	36.93	.44	5	62.34	16.37	.26	.107
Jackson	3	89.87	11.69	.13	2	45.32	.79	.02	**.008**
Marianna-like	2	121.23	30.02	.25	1	71.99	0.00	.00	d
Pinellas	23	32.37	18.19	.56	10	24.55	7.88	.32	**.048**[e]
Santa Fe	4	109.83	19.13	.17	1	114.63	0.00	.00	d
Sarasota	4	169.31	59.60	.35	1	203.21	0.00	.00	d
Taylor	3	89.81	34.28	.38	1	90.60	0.00	.00	d
Westo					4	85.27	40.19	.47	g

[a] Original size data from Austin et al. 1992 and unpublished data; Austin and Ste. Claire 1982 and unpublished data; Chance 1983a; Chance and Misner 1984, Daniel and Wisenbaker 1979; Deming et al. 1984b; Estabrook 1990, 1991; Estabrook and Newman 1984; Gagel 1981; Hemmings and Kohler 1974; Meadows 1995; Ste. Claire 1983; Williams and Estabrook 1987; Willis 1988; Wolf 1975.

[b] Raw size data in Appendix E.

[c] Probability for making a Type I (alpha) error. Bold entries indicates alpha levels (one-tailed) for significant values of *t* ($\leq .05$).

[d] No *t* test conducted since study collection sample consists of only a single specimen.

[e] Levene's test for unequal variances indicates significant differences between the test samples; therefore, a student's *t* test comparing samples with unequal variances was used.

[f] Generic Florida Archaic Stemmed. Could not be assigned with confidence to specific types.

[g] No *t* test conducted since no comparative data could be found.

seven of the 11 post-Archaic types (Bradford, Broward, Columbia, Copena, Hernando, Jackson, and Pinellas). The only Archaic type that exhibits a mean size index that is higher than the control sample is the Hardee point. The Santa Fe and Marianna points are usually assigned to the late Paleoindian or Early Archaic periods (Bullen 1975:6); however, recent stratigraphic and radiocarbon data from a number of sites in Florida indicate that the Santa Fe point is probably a late-Archaic or early Woodland type (Austin 1995b; Austin et al. 1992; Mikell 1997). The Marianna point has rarely been found in stratified or dated contexts making its temporal assignment uncertain, although a similar-looking biface was excavated recently from a Woodland period component in Sumter County (Estabrook 1995). The single example of this latter type in the study collection is from Fort Center (8GL13). I have cautiously identified it as Marianna-like, and assigned it to the post-Archaic period. Of the two types, the Marianna has a size index that is smaller than the mean size index for specimens in the control sample while the Santa Fe is larger.

A series of *t* tests was conducted on 17 of the 23 types to determine if the differences between sample means are significant. Six biface types (Copena, Greenbriar, Marianna-like, Santa Fe, Sarasota, and Taylor) were represented in the study collection by only a single specimen each and were not included in the statistical analysis. The research hypothesis that the mean size indices of the hafted-biface types in the study collection would be smaller than the control sample required that the test of sample means be a directional one, or one-tailed (Blalock 1972:163). The alpha level was set at .05, which for a one-tailed test indicates that there is a 5 percent chance of erroneously rejecting the null hypothesis that the mean size indices for the study collection are equal to or greater than the control sample. The raw size-index data for individual specimens representative of each of the 17 hafted-biface types were compared with the raw size-index values for corresponding hafted-bifaces types in the control sample using the SPSS for Windows™ Student's *t* test for two independent samples. An assumption of the Student's *t* test is that the two samples possess equal variances. The SPSS program calculates Levene's Test for Uneven Variances and provides a measure of the probability that the variances of the two samples are significantly different. When this test indicated that the variances of two samples differed significantly, the *t* value for samples with uneven variances was used instead of the more conventional Student's *t*. Those hafted-biface types in the study collection that were determined to be statistically smaller than their corresponding types in the control sample are indicated in Table 52 along with their associated probabilities for erroneously rejecting the null hypothesis.

The results of the *t* tests indicate that five of the 17 hafted-biface types included in the statistical analysis possess mean size-indices that are significantly smaller than the mean values for their corresponding types in the control sample. Three of these are Archaic types (Bolen, Marion, and Putnam). The *t* value for a fifth Archaic type (Hillsborough) was just below the critical value of *t* for rejection of the null hypothesis, possessing an alpha value of .055. The two post-Archaic types that were determined to have mean size indices that are significantly smaller than the control sample are the Jackson and Pinellas types.

At first glance, the results of the *t* tests seem unusual because some of the differences in the mean size indices are quite large. For example, the mean size index of 148.91 for three Culbreath points in the study collection is substantially smaller than the mean size index of 245.42 for 35 specimens in the control sample. However, the individual size indices for the control sample range from a low of 96.32 to a high of 541.2 with a standard deviation of 114.35 and a coefficient of variation (i.e., the standard deviation expressed as a proportion of the mean) of .47. The standard deviation for the three specimens in the study collection is 58.30 with a coefficient of variation of .39. Two of the individual size indices cluster closely together (103.62 and 128.43) while the third is nearly twice as large (214.70). These data indicate that there is an overlap of individual specimen values between the two samples, and that the overlap is large enough to affect the value of *t*. This problem is especially acute when one of the samples is small, as is the case with most of the samples of hafted-biface types in the study collection, which makes the mean and standard deviation more sensitive to extreme values (see, for example, the individual size index values for Bradford, Broward, Columbia, and Newnan projectile points in Appendix E). For this reason, I place more interpretive weight on the dominant pattern of smaller tool-size indices that is exhibited by the hafted-biface types in the study collection than I do on the results of the Student's *t* tests.

When the size indices for individual specimens within each hafted-biface class are examined (Appendix E), it is apparent that Fort Center (8GL13), and to a lesser extent Pineland (8LL33, 36, 37), have some of the largest examples of many of these hafted-biface types. This is well illustrated by the data in Table 53 where the mean indices for hafted-biface types in the study collection have been recalculated without the specimens from Fort Center These recalculated values have been compared to the mean size indices of the Fort Center specimens. The data indicate that for 9 of the 13 hafted-biface types present at Fort Center for which there are comparative data from the other sites in the study collection, the mean size indices are larger than the mean indices for all other hafted-bifaces in the study collection. The four hafted-biface types in the Fort Center collection that have size indices lower than the means for the study collection are Levy, Newnan, Pinellas, and the diminutive Archaic stemmed points. Three other hafted-biface types are represented by only a single specimen each from Fort Center and so could not be compared to the study collection. In 8 of 13 cases where there was at least one other specimen for comparison with Fort Center, the Fort Center assemblage contained the largest example of each type. In two of the remaining four cases the Fort Center assemblage contained the second largest examples, and in the remaining two cases the Fort Center assemblage contained the fourth largest examples. In many cases, when the Fort Center specimens are removed from the overall study collection samples, the mean indices for individual hafted-biface types drop substantially. In one case (Bradford points) the mean size index for the study collection was determined to be significantly smaller than the control sample after removal of the Fort Center specimens ($p = .049$).

Table 53. Comparison of mean size indices of hafted bifaces at Fort Center (8GL13) with the mean size indices of all other hafted bifaces in the study collection.

Hafted-Biface Type	Study Collection[a]				Fort Center			
	N	Mean	SD	CV	N	Mean	SD	CV
Archaic Types								
Culbreath	1	128.43	.00	.00	2	159.16	78.54	.49
Hardee	3	103.86	47.87	.46	2	211.91	51.37	.24
Hillsborough	1	56.29	.00	.00	1	120.87	.00	.00
Levy	9	147.25	68.30	.46	1	133.25	.00	.00
Marion	23	139.97	69.04	.49	7	184.11	114.34	.62
Newnan	13	168.34	91.00	.54	1	69.90	.00	.00
Putnam	9	132.66	61.24	.46	1	218.22	.00	.00
Diminutive FAS	12	87.12	64.20	.74	7	67.21	40.79	.61
Post-Archaic Types								
Bradford	2	65.54	40.65	.62	1	352.64	.00	.00
Broward	3	169.27	48.67	.29	1	214.64	.00	.00
Columbia	2	155.09	44.77	.29	4	158.74	41.49	.26
Hernando	2	45.14	2.76	.06	3	73.80	6.27	.08
Pinellas	6	24.97	7.35	.29	4	23.92	9.76	.41

[a] Hafted bifaces in the study collection minus Fort Center specimens.

NOTE: Copena, Marianna-like, and Santa Fe points were not included in this table since the only examples in the study collection are from Fort Center.

The amount of variability in size indices is itself an important feature of these assemblages. When the size indices of the most common Archaic types (Levy, Marion, Newnan, Putnam, and undifferentiated Florida Archaic Stemmed) are plotted versus distance to chert sources (Figure 65a), the resulting distance-decay pattern exhibits a very gradual slope (r = -.189, r^2 = .036, p = .032), unlike the core data which exhibit a more rapid fall-off (cf. Figures 57 and 58). Even though the trend is towards

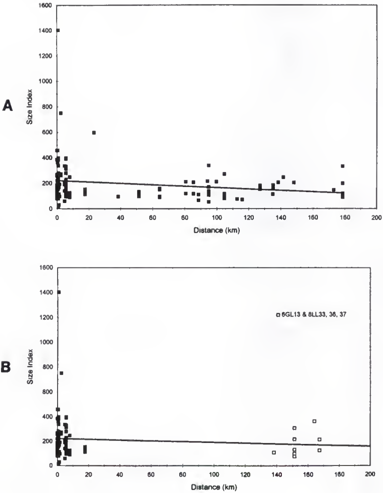


Figure 65. Relationship between Archaic hafted-biface size and distance to chert resources: a) 8GL13 and 8LL33, 36, 37 specimens not included; b) 8GL13 and 8LL33, 36, 37 specimens only.

progressively smaller bifaces with distance, the spread of size index values around the regression line illustrates the variability that is present in the Archaic hafted-biface assemblage. The gradual fall-off pattern coupled with the variability in hafted-biface sizes most closely resembles the hypothesized pattern of hafted-biface discard for mobile populations leaving and returning to lithic source areas as part of a yearly or seasonal settlement round (cf. Figure 16b, Chapter 6).

In Figure 65b, the size indices of Archaic hafted bifaces from Fort Center and Pineland are plotted versus distance to chert sources. The pattern is similar to that exhibited in Figure 65a,although the slope is even more gradual and the relationship between size and distance is not statistically significant ($r = -.09$, $r^2 = .008$, $p = .607$). Even though slightly larger-than- average specimens ended up at Fort Center to be deposited in sacred contexts (see Chapter 9), this similarity in distance-decay patterns suggests that the Archaic bifaces that entered Fort Center and Pineland are salvaged specimens that reflect the general population of Archaic hafted bifaces in south Florida. This does not necessarily negate the interpretation that these bifaces entered the site through exchange, but it does support the hypothesis that these bifaces were not made at Fort Center.

Post-Archaic hafted bifaces exhibit much different distance-decay patterns (Figure 66). Unfortunately, there are not as many comparative size data from sites near chert sources; however, the patterns exhibited by the four hafted-biface types in Figure 66 indicate a great deal of variability in terms of the relationship between size and distance. For example, Broward and Bradford points display increases in size with distance while Hernando and Columbia points decrease in size. The patterns for Broward and Bradford points are similar to the pattern hypothesized in Chapter 6 for directed prestige exchange (see Figure 16d) while the Hernando projectile-point pattern is similar to the hypothesized pattern for down-the-line exchange (see Figure 16a) since the range of variability in size indices at distant locations is relatively narrow. Although no size data for Columbia points from sites located near a chert source were available, the mean size index for two examples reported in Robinson (1979:14) as

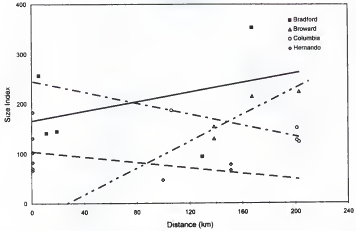


Figure 66. Relationship between selected post-Archaic hafted-biface size and distance to chert resources.

coming from Pinellas and Pasco counties is 203.58, which suggests that the decrease in size shown in Figure 66 also could be the result of down-the-line-exchange.

Summary. These data support the hypothesis that tool size should be smaller in areas where chert is not abundant. Furthermore, the pattern appears to hold for both the Archaic and post-Archaic periods. However, the underlying cause(s) of this reduction in size is not clear. For example, the variability in size indices exhibited by the Archaic and post-Archaic hafted-biface types appears to be more strongly related to different forms of procurement than to portability per se. The variability in individual specimen sizes among many of the Archaic hafted-biface types may be a reflection of the transport of large, thin preforms and/or finished implements away from chert source locations and the subsequent planned staging of reduction and resharpening episodes to ensure that a sufficient supply of lithic raw material was available for use until the group could return to a chert source for reprovisioning. As discussed in Chapter 6, this strategy would result in a variety of tool sizes being discarded in the archaeological record and a relatively gradual distance-decay pattern. Thus, the smaller mean sizes may simply be the result of repeated and extensive resharpening.

On the other hand, several post-Archaic hafted bifaces exhibit variable distance-decay patterns suggesting both prestige and down-the-line exchange. The former would result in generally larger specimens occurring at a distance from source locations while the latter would exhibit a gradual and consistent decline in size with a small range of variation at locations located farthest from chert sources. In this regard it is worth noting the comparatively larger examples of many hafted-biface types at Fort Center. The occurrence of these large bifaces in contexts that suggest use by craft specialists (Mound A) and interment as grave goods (Mound B and the charnel pond) suggests that large hafted bifaces may have been targeted for high-status individuals at this site.

Cortex

The proportion of cortex flakes should diminish in lithic assemblages that are located at progressively greater distances from a lithic source location as a result of reducing the amount of waste material that is transported. Data on the presence of dorsal cortex were collected in much the same way as core-size data. In addition to data from sites in the study collection, archaeological reports from sites located primarily in chert-bearing locales also were reviewed for data on flake cortex. There is a certain amount of inconsistency in the identification of primary, secondary, and nondecortication flakes by different analysts. Some include only flakes with their entire dorsal surfaces covered with cortex in the primary category, while others include flakes with anywhere from 50 to 90 percent of their dorsal surfaces covered in cortex in this category. Similarly, nondecortication flakes may include flakes with as much as 10 percent of their dorsal surfaces covered with cortex. In many cases, the criteria used to identify primary, secondary, and nondecortication flakes are not made explicit. Furthermore, some analysts simply make a distinction between cortical flakes and nondecortication flakes. For these reasons, I have chosen to collapse the primary and secondary decortication categories into a single category -- "Cortex Flakes." This enables me to use a ratio of cortex to noncortex flakes (C:NC) that can be plotted against distance to chert sources. Table 54 provides the raw data for cortex and noncortex flakes for all of the sites used in this analysis. As with cores, the sites analyzed for this study have been subdivided by raw-material type and these types are identified by letters in parentheses following the site numbers. I also have included flake tools in the debitage totals of study-collection assemblages since most of these are the result of the reduction of raw materials that were imported to these sites.

Figure 67a shows the distribution of C:NC ratios versus distance to chert sources for Archaic period sites and components. Only one site has a ratio greater than 1.4; this is the Fowler Avenue Bridge site (8HI393c/uw) with a ratio of 7.34. This ratio may be biased, however, by the transport of small flakes by flowing river water at this inundated quarry site (Palmer et al. 1981:56-58) which may have inflated the numbers of large, cortical flakes removed during early stages of core preparation and reduction. The possibility of such a bias is highlighted by comparing this site with the Wetherington Island site (8HI473), a dry-land quarry site with a C:NC ratio of 1.38. Although high in comparison to other, non-quarry sites, this ratio is much lower than 8HI393c/uw, and is probably more representative of the range of reduction stages represented at a quarry site. Regardless of the reason, the very high C:NC ratio at 8HI393c/uw masks the underlying relationship of the other data points in the graph, and so was dropped from the analysis.

With this site removed, a general trend of decreasing dorsal cortex with distance to chert resources is evident (Figure 67b). A rapid drop-off in the C:NC ratios within the first 5-10 km is followed by a general leveling off of the ratios with distance. However, the scatter of data points is too great to enable an exponential curve to be fitted to the data. The best fit is achieved with a linear regression equation which provides a moderately high r value of -.500 with an $r^2 = .250$. While this correlation is significant ($p = .001$), five data points appear to be outliers. These include three assem-

Table 54. Raw data on cortex (C) versus noncortex (NC) flakes for Archaic and post-Archaic assemblages.

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
Archaic Assemblages					
8HA180	0	3526	8596	.41	Ste. Claire 1995
APAFR[e] (HR/SC)	103.0	5	35	.14	This study
APAFR[e] (CHC)	125.5	1	13	.08	This study
APAFR[e] (T3/T4/BB)	131.2	2	24	.08	This study
8HG35(HR/SC)	82.1	0	16	.00	This study
8HG35(W)	94.9	3	21	.14	This study
8HG51(HR/SC)	96.6	12	83	.14	This study
8HG51 (T3/T4/BB)	123.9	1	18	.06	This study
8HG51(W)	117.5	2	26	.08	This study
8HG51(PR)	51.5	55	342	.16	This study
8HG678(HR/SC)	93.3	2	15	.13	This study
8HG767(HR)	86.1	1	12	.08	This study
8HG767(PR)	47.5	1	13	.08	This study
8HI43	1.6	163	255	.64	Daniel and Wisenbaker 1979:39-40

Table 54 (Continued).

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
8HI89	0	765	2235	.34	Deming et al. 1984a:29-30
8HI393c/uw	0	3875	528	7.34	Palmer et al. 1981:Table 1
8HI452[f]	5.6	1388	9972	.14	Estabrook and Newman 1984:Tables 22, 26-29, 32, 37-39, 43, 47-50
8HI473[g]	0	4922	3572	1.38	Chance 1982: Tables III, V, VII; Chance and Misner 1984 Tables 5-6, 9-10, 15-16, 17, 20-21
8HI476A[h]	4.8	5221	27248	.19	Chance 1983a:Tables 10-11
8HI483A	2.4	1485	2828	.53	Daniel 1982:Table 15
8HI557	5.6	1692	5570	.30	Austin and Ste. Claire 1982:Table 8
8HI559	5.6	82	251	.33	Austin and Ste. Claire1982:60
8HI2187[i]	3.2	207	682	.30	Williams and Estabrook 1988:26
8HI3281[j]	<.5	430	1644	.26	Williams and Estabrook 1987:Table 5
8HI5446	.8	3678	12003	.31	Meadows 1995:Tables 4-5
8HR68(HR/SC)	29.8	18	141	.13	This study
8HR68(CHC)	56.3	6	21	.29	This study

Table 54 (Continued).

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
8HR68(T4/BB)	56.3	0	35	.00	This study
8HR68(PR)	27.4	0	12	.00	This study
8HR71(HR/SC)	35.4	21	124	.17	This study
8HR71(CHC)	61.2	4	11	.36	This study
8HR71(W)	66.0	7	52	.14	This study
8HR92(HR/SC)	38.6	26	244	.11	This study
8HR92(CHC)	63.6	3	41	.07	This study
8HR92(T3/T4/BB)	56.3	4	35	.11	This study
8HR92(W)	67.6	7	53	.13	This study
8HR92(PR)	18.5	4	20	.20	This study
8LV128	20.9	144	3062	.05	Gagel and Tesar 1978:Tables 45-56
8MR507[f]	0	1694	5621	.30	Ste. Claire 1983:25-26
8MR510	<.5	3051	16628	.18	Ste. Claire 1983:25-26
8OS123	39.4	54	420	.13	Estabrook 1991:56
8PI66	<.5	2979	5083	.59	Wolf 1975:Table 7

Table 54 (Continued).

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
Post-Archaic Sites					
8GL13(HR/SC)	151.3	35	164	.21	This study
8GL13(T3/T4/BB)	164.1	2	18	.11	This study
8GL13(W)	167.4	3	15	.20	This study
8GL13(PR)	88.5	1	30	.03	This study
8GL13(COB)	88.5	194	84	2.31	This study
APAFR[e] (HR/SC)	103.0	15	140	.11	This study
APAFR[e] (CHC)	125.5	5	26	.19	This study
APAFR[e] (T3/T4/BB)		1	17	.06	This study
APAFR[e] (W)	112.7	3	29	.10	This study
8HG678(HR/SC)	93.3	2	29	.07	This study
8HG678(PR)	55.5	2	25	.08	This study
8HI471	9.0	606	1255	.48	Austin 1982:Table 9
8HI480	25.7	66	169	.39	Almy 1981:Tables G1-G4
8HI556	.8	3522	7072	.50	Austin and Ste. Claire 1982:156,Tables 21-22

Table 54 (Continued).

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
8HI558[k]	5.6	613	1673	.37	Estabrook and Newman 1984:Tables 15-18
8HI981	4.0	35	391	.09	Estabrook and Williams 1992:Table 1
8HI2126	1.2	413	1720	.24	Deming et al. 1984b:86-87
8HR44(PR)	14.5	28	127	.22	This study
8HR48(HR/SC)	40.2	6	46	.13	This study
8HR48(PR)	13.7	23	53	.43	This study
8LL33,36,37(HR)	115.1	14	24	.58	This study
8LL33,36,37 (T3/T4)	142.4	6	9	.67	This study
8LL33,36,37(DO)	1	7	3	2.33	This study
8PA70	8.0	71	253	.28	Deming and Almy 1982:Table 5
8PI894B	5.6	99	496	.20	Austin and Estabrook 1991:Table 11
8PI1753(HR)	12.9	41	46	.89	This study
8PI1753(SC)	19.3	3	17	.18	This study
8PI1753(CHC)	35.4	6	13	.46	This study
8PI1753(T3/T4)	11.3	25	66	.38	This study

Table 54 (Continued).

Site[a]	Distance (km)[b]	Cortex Flakes[c]	Noncortex Flakes	C:NC Ratio[d]	References
8PI1753(TCP)	6.4	55	12	4.58	This study

[a] Letters in parentheses refer to chert quarry clusters or types: BB = Bay Bottom chert (Type 5), Hillsborough River Quarry Cluster; C = Caladesi Quarry Cluster; CHC = Cow House Creek chert, Hillsborough River Quarry Cluster; COB = cobbles, Tampa Limestone chert, DO = dolomite; HR = Hillsborough River Quarry Cluster; O= Ocala Quarry Cluster; PR = Peace River Quarry Cluster; SC = silicified coral; T3 = Type 3 chert, Hillsborough River Quarry Cluster; T4 = Type 4 chert, Hillsborough River Quarry Cluster; TCP = Turtlecrawl Point Quarry Cluster, W = Withlacoochee River Quarry Cluster.

[b] Distances are straight-line measurements between a site and the nearest chert exposure.

[c] Includes primary and secondary decortication flakes.

[d] Ratio of cortex (C) to noncortex (NC) flakes.

[e] Debitage from 8HG18, 8HG20, 8HG27, and 8HG34 located on the Avon Park Air Force Range (APAFR) were combined to increase the sample sizes for different raw-material types.

[f] All flakes from shovel tests, only platform-bearing flakes from excavation units.

[g] 1982 data are from three selected excavation units; 1984 data represent random samples ranging from .5 to 15 percent that were analyzed from various subareas of the site.

[h] Debitage from only two of three subareas reported.

[i] May include shatter flakes.

[j] Only 2 of 8 test units analyzed.

[k] Platform-bearing flakes only.

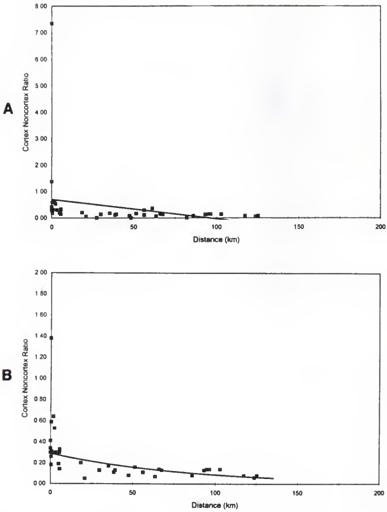


Figure 67. Relationship between cortex-to-non-cortex ratios and distance to chert resources for a) Archaic period sites and b) with 8HI393c/uw removed.

blages with C:NC ratios of 0 (8HG35[HR/SC], 8HR68[BB], and 8HR68[PR]) and two data points that are greater than expected given their distances from a chert source (8HR71[CHC] and 8HR68[CHC]). If these data points are removed, an exponential curve can be fitted to the data resulting in a stronger correlation ($r = -.699$, $r^2 = .489$) that is statistically significant ($p = .023$).

Figure 68a shows a similar plot for post-Archaic assemblages. It is immediately apparent that this distribution displays more variability than the Archaic distribution in Figure 67. For one thing, three sites have C:NC ratios greater than 1 and several sites approach this value. Second, several of the sites with high C:NC ratios are located at some distance from a chert source. The best fit is a power function equation; however, the relationship is not strong ($r = -.396$, $r^2 = .157$, $p = .611$). Eliminating the three outlying data points (8GL13[COB], 8LL33,37[DO], and 8PI1753[TCP]) improves the correlation somewhat (Figure 68b), but not much. The best fit remains a power curve which reflects the relatively rapid drop-off of ratio values within 25 km of a chert source, but there still remains a great deal of variability beyond this distance, particularly when compared to the Archaic data in Figure 67b which are plotted at a similar scale. This variability also is reflected by the low r value of -.365 and the low r^2 value of .134 ($p = .084$) which indicates that only about 13 percent of the variability exhibited by the C:NC ratio values can be explained by distance to chert resources using this equation.

Summary. As with the core data, the most interesting observation regarding cortex is the degree of variability exhibited by the post-Archaic sites. It also is interesting that many of the data points that were removed as "outliers" from this analysis are the same assemblages that had data points removed from the core-size analysis, specifically Fort Center (8GL13), Pineland (8LL33,36, 37), and Yat Kitischee (8PI1753). Moreover, of the assemblages retained in Figure 68b, Pineland contains two of the highest C:NC ratios for "generic" Hillsborough River Quarry Cluster cherts and for the combined Type 3 and Type 4 Hillsborough River cherts. This further reinforces the interpretation that these sites represent different chert acquisition patterns than do other post-Archaic sites included in this study.

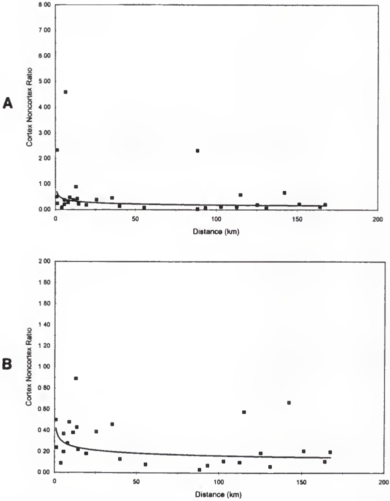


Figure 68. Relationship between cortex-to-non-cortex ratios and distance to chert resources for a) post-Archaic sites and b) with outlying data points removed.

Another temporal difference is the more rapid fall-off in C:NC ratio values for Archaic assemblages, with the fall-off boundary occurring within 5-10 km of chert sources, the same as for core size and weight. The leveling off of C:NC ratios for post-Archaic sites does not occur until distances greater than 25 km. Furthermore, the spread of values at these distances (i.e., < 25 km) is large indicating that there is variation in the acquisition and use of chert that may be related to different procurement strategies (i.e., direct versus indirect) or site function (i.e., habitation versus extractive campsites).

Three post-Archaic sites exhibit C:NC ratios greater than 1. When the specific raw materials associated with these data points are examined, an interesting pattern emerges. The Fort Center debitage with a C:NC ratio of 2.31 is from chert that occurs at this site in the form of small, rounded cobbles that are suspected to have been derived from either the Hillsborough River or Peace River quarry clusters. Distance to the latter was used as a more conservative measure. More importantly, these cobbles were imported to the site in complete or nearly complete forms with much of their external cortical surfaces intact. Thus, reduction of these cobbles on site resulted in a high C:NC ratio for this material. A similar situation exists for the Turtlecrawl Point, Type 1 chert debitage from Yat Kitischee that was derived from the reduction of small, rod-shaped pieces of chert. The exact provenience of these chert "rods" is unknown, but the nearest documented source of Turtlecrawl Point chert is Largo Inlet, about 6.4 km away. Again, these chert rods were brought to the site intact with a high degree of external cortex present. Reduction on-site resulted in a very high C:NC ratio of 4.58 for this raw material. Finally, the flakes of dolomite from Pineland exhibit a C:NC ratio of 2.33. This material is considered to be local in origin and was probably used as an experimental replacement for chert. Thus, these three raw materials, even when imported from some distance, as in the case of chert cobbles at Fort Center, were in essence treated as local raw materials with initial stages of reduction occurring at the habitation site.

Lithic Economizing

Where lithic raw materials are limited or non-existent, the cost of procuring these resources can be reduced by using available materials more intensively, i.e., by practicing economizing strategies. Economizing strategies may include more intensive efforts to rejuvenate the working edges of both shaped and unshaped tools, greater and more intensive use of available flake-tool margins, and more intensive use of available flakes for expedient tool use.

Tool Maintenance

Hafted bifaces. Many of the hafted bifaces from sites in the study area display evidence of edge rejuvenation and resharpening, with modification of blade-edge morphology ranging from slight to extensive. In order to evaluate objectively the degree to which tool maintenance occurred, two indices were computed for all complete or nearly complete hafted bifaces: a mid-blade width to basal-blade width ratio (MBW:BBW) and a blade length to basal-blade width ratio (BL:BBW). Because the base and stem of a hafted biface are usually attached to a shaft, basal-blade width will tend to remain constant throughout the use life of a tool unless there is breakage of the proximal end (Hoffman 1985; Keeley 1982). Basal-blade width can thus be used as a constant in deriving formulae for monitoring blade reduction due to resharpening.

Two forms of resharpening are observable in the archaeological record (Figure 69). Resharpening of the lateral margins occurs most frequently when hafted bifaces are used for scraping or cutting tasks, while resharpening that focuses on the distal end of an implement should be most common when bifaces are used as projectiles. Hafted bifaces that have experienced a high degree of lateral resharpening should have a mid-blade width that is narrower relative to basal-blade width than bifaces that have experienced no or very little lateral resharpening (Figure 69a). While it is possible to have a biface with a midblade wider than its basal blade (e.g., Bullen 1975: 10, 17, 22, 36), only a few

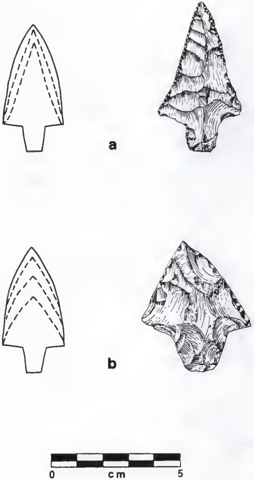


Figure 69. Examples of distal and lateral-margin resharpening of hafted bifaces from sites in the study area: a) lateral-margin resharpening, State Road 70; b) distal resharpening, Lake Livingston.

specimens in the study collection exhibited such a morphology and these were not included in this analysis. Thus, I assume a maximum possible MBW:BBW value of 1.0, which would indicate a mid-blade width that is equal to the basal-blade width.

Bifaces that have been subject to resharpening of their distal ends should exhibit a reduction in blade length relative to their basal-blade width (Figure 69b); in other words, they should possess a low BL:BBW ratio (Shott 1986:44). Blade length is defined as the maximum distance from the distal apex of the biface to the intersection of the haft element and basal-blade margin.

To determine if the hafted bifaces in the study collection had experienced significant lateral or distal resharpening, it was necessary to compare the resulting ratios to a control sample. Ideally, this sample should consist of hafted bifaces from a chert-rich area where it can be assumed that raw-material conservation, and hence tool maintenance, would be less pronounced. To accomplish this, I calculated MBW:BBW and BL:BBW ratios for comparable hafted-biface types using the dimensional data published in Robinson (1979). This source provides maximum width measurements in centimeters for a number of individual specimens in private collections, most of which come from sites in west-central and north-central Florida. One-to-one scale outlines of individual projectile points also are provided and these were used to obtain measurements of blade length and mid-blade width. Since the basal-blade width for most hafted-biface types is effectively the maximum width of a specimen, the maximum width measurements from Robinson could be used directly for this variable. To check the accuracy of these data, measurements of basal-blade width were made of a sample of Robinson's outlines and these were compared to his maximum-width measurements for each specimen. The differences rarely exceeded a few millimeters. Since Robinson's measurements were made on the original specimens, his width measurements were used as a substitute for basal-blade width. For those hafted-biface types where maximum width and basal-blade width were clearly different, basal-blade width was measured directly from the outlines.

Because the size ranges of different hafted-biface types vary, it was necessary to devise a standardized measure of comparison. This was accomplished by standardizing the individual specimen ratio values to an overall type mean. Since I had hypothesized that the bifaces in the study collection would possess ratio values that are smaller than those from a chert-rich area, I did not want to include the raw values of the study collection bifaces in the calculations of type means since these could potentially bias the means downward. Thus, the type means were calculated using only the data from the control sample (i.e., the Robinson data). The standardized ratios are calculated by dividing the individual specimen ratios by the control sample mean and subtracting the result from 1. The resulting value provides an indication of how much an individual specimen's ratio value differs from the mean ratio value for that type based on the control sample data. To illustrate this, a Levy projectile point with a MBW:BBW ratio of .5 is compared to a type mean of .65, calculated from the control sample for Levy points. The resulting normalized value of -.23 (.5 ÷ .65 = .77 - 1 = -.23) indicates that the MBW:BBW ratio for this specimen is 23 percent below the control-sample average for Levy points.

Table 55 provides summary data and mean ratios (normal and standardized) for the various hafted-biface types in the study collection and the control sample. Raw data for individual specimens in the study collection can be found in Appendix E. A few hafted-biface types that are present in the study collection (e.g., Hardee, Santa Fe, Copena-like, and Marianna-like) are not included in this analysis because type identifications were not definitive or they were not represented in Robinson (1979).

The data in Table 55 indicate that most of the mean BL:BBW ratios for the various hafted-biface types in the study collection are smaller than the comparable mean ratio values in the control sample. In fact, only five hafted-biface types have mean BL:BBW ratios that are higher than the control-sample means, and four of these are post-Archaic types (Hernando, Jackson, Sarasota, and Taylor). Many of the hafted-biface types also possess mean MBW:BBW ratios that are smaller than

Table 55. Mean size indices, mid-blade width:basal-blade width (MBW:BBW) ratios, and blade length:basal-blade width (BL:BBW) ratios for hafted-biface types represented in the study collection.

Hafted-Biface Type	Control Sample[a]				Study Collection[b]						
	N	Size Index	MBW: BBW Ratio	BL: BBW Ratio	N	Size Index	Stand. Index[c]	MBW: BBW Ratio	Stand. Ratio[c]	BL: BBW Ratio	Stand. Ratio[c]
Archaic Types											
Bolen	36	100.20	.66	1.51	3	45.10	-.55	.68	.03	1.28	-.15
Culbreath	28	233.12	.77	1.22	3	148.91	-.36	.60	-.22	1.18	-.03
Greenbriar	16	98.76	.78	1.51	1	51.58	-.48	.66	-.16	.92	-.39
Hillsborough	16	135.10	.70	1.44	2	117.89	-.13	.66	-.05	1.42	-.01
Levy	16	262.40	.65	1.40	11	152.18	-.42	.60	-.08	1.12	-.20
Marion	20	311.36	.74	1.32	29	151.43	-.51	.68	-.07	1.02	-.22
Newnan	21	205.81	.78	1.68	13	157.49	-.23	.68	-.13	1.11	-.34
Putnam	10	265.70	.78	1.50	10	141.22	-.47	.69	-.11	1.10	-.27
Sumter	6	227.85	.86	1.21	3	218.44	-.04	.86	.00	1.42	.18
FAS[d]	46	284.40	.72	1.38	3	152.34	-.46	.84	.17	1.17	-.15
Post-Archaic Types											
Bradford	10	162.66	.78	1.73	3	196.06	.21	.73	-.07	1.08	-.38
Broward	3	223.18	.82	2.15	4	180.61	-.19	.84	.02	1.79	-.17
Columbia	2	203.58	.82	2.36	6	157.52	-.23	.78	-.05	1.93	-.18

Table 55 (Continued)

Hafted-Biface Type	Control Sample[a]				Study Collection[b]						
	N	Size Index	MBW: BBW Ratio	BL: BBW Ratio	N	Size Index	Stand. Index[c]	MBW: BBW Ratio	Stand Ratio[c]	BL: BBW Ratio	Stand. Ratio[c]
Duval	10	76.34	.73	2.49	3	119.88	.57	.68	-.07	2.06	-.17
Hernando	32	78.95	.61	1.78	5	62.34	-.21	.66	.07	2.09	.17
Jackson	2	87.10	.71	1.49	3	62.02	-.29	.74	.04	1.55	.04
Pinellas	17	38.65	.66	2.12	10	24.55	-.36	.65	-.01	1.85	-.13
Sarasota	2	166.89	.78	1.98	1	203.21	.22	.85	.09	2.41	.22
Taylor	3	89.81	.71	1.16	1	90.60	.01	.94	.09	1.38	.19

[a] Based on dimensional data and measurements of projectile-point outlines in Robinson (1979)

[b] Raw data in Appendix E

[c] Ratios standardized to a proportion of the type mean minus 1.

[d] Archaic-stemmed projectile points that could not confidently be assigned to a specific type. Comparative data were generated using data derived from a combined sample of Florida Archaic Stemmed types, i.e., Levy, Marion, and Putnam.

the control-sample means. The standardized MBW BBW values indicate that seven of the ten Archaic types possess mean ratio values that are lower than the control-sample means. Four Archaic types possess MBW BBW ratios that are 10 percent or more below the control-sample means, with a maximum of -.22, or 22 percent, for Culbreath points. These low MBW·BBW width values indicate a high degree of lateral resharpening for these Archaic hafted-biface types. In comparison, only four of the nine post-Archaic types possess mean MBW:BBW ratios that are smaller than the control-sample means, and the differences are all less than 7 percent, well within one standard deviation of the control-sample means.

These data indicate that the hafted bifaces in the study collection, particularly the Archaic types, were subjected to greater amounts of edge rejuvenation than similar hafted bifaces from chert-rich areas. However, the use of mean values masks the variability that is present in both the control-sample and the study-collection data. Furthermore, it is not clear whether the low ratios of blade length to basal-blade width are the result of distal resharpening or simply smaller tool size. To address these issues the individual standardized values for the MBW:BBW and BL:BBW ratios were plotted versus similarly standardized size indices computed for individual specimens. Because the standardized ratio and size-index values are either positive or negative depending on whether they are larger or smaller than the control-sample means, it is possible to interpret the resulting bivariate graphs by dividing them into quadrants (Figure 70). For both the MBW:BBW and BL:BBW ratios, the upper two quadrants indicate minimal resharpening since the standardized ratio values are positive (i.e., larger than the control-sample means). Specimens that fall into the upper left quadrant are smaller in size than average for the type and those that fall in the upper right quadrant are larger than average. The lower two quadrants indicate either lateral-margin or distal resharpening since the standardized ratio values are negative (i.e., smaller than the control-sample means). Specimens that fall into the lower left quadrant are smaller in size than average and those in the lower right quadrant are larger than average. By plotting the standardized ratio

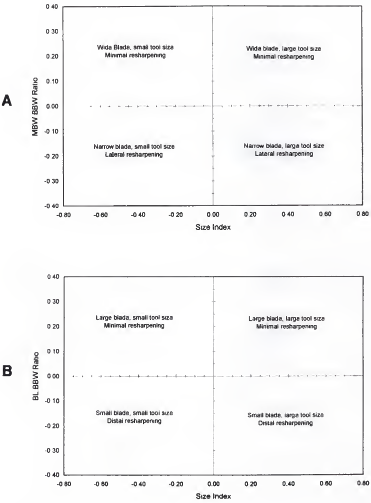


Figure 70. Expectations of blade resharpening model: a) size index versus ratio of mid-blade width to basal-blade width; b) size index versus ratio of blade length to basal-blade width.

values versus standardized size indices it is possible to examine whether or not a hafted biface of a particular size (i.e., larger or smaller than average) exhibits greater or lesser amounts of distal or lateral-margin resharpening when compared to other hafted bifaces of a similar size.

Examination of the bivariate graphs for Levy, Marion, Newnan, and Putnam projectile points (Figures 71-74) illustrate nicely how this is achieved. As these figures show, the study collection specimens are consistently found on the left side of the bivariate graphs, with a tendency for most of the specimens to fall in the lower left quadrant. This indicates that for these four hafted-biface types, the individual specimens in the study collection tend to exhibit a consistent pattern of distal and lateral resharpening when compared to specimens of a similar size in the control sample. Moreover, the fact that most of the study-collection specimens are smaller than the control-sample specimens, and that most of these specimens are located in the lower left quadrant of the BL:BBW graph (i.e., smaller-than-average size and smaller-than-average BL:BBW ratio) indicates that the generally smaller tool sizes for these hafted-biface types are probably due to distal resharpening.

These patterns are repeated for Bolen, Culbreath, Greenbriar, and Hillsborough points (Figures 75-77). All of the examples of these hafted-biface types that are present in the study collection fall on the left side of the bivariate graphs indicating that they are smaller than average. Many of the individual specimens have standardized size indices that indicate that they are more than 20 percent smaller than the mean size indices for comparable specimens in the control sample (Appendix E). The Bolen and Greenbriar points are especially small, with two Bolen points possessing standardized size indices of -.83 and -.57. The Greenbriar point possesses a standardized size index of -.48. Mid-blade width to basal-blade width ratios for these specimens are typically higher than average, but BL:BBW ratios are quite low indicating that the small sizes of these implements are partly the result of excessive distal resharpening. Culbreath points exhibit low MBW:BBW values while BL:BBW ratios hover around the control-sample mean indicating that tool maintenance of these hafted bifaces focused on lateral-

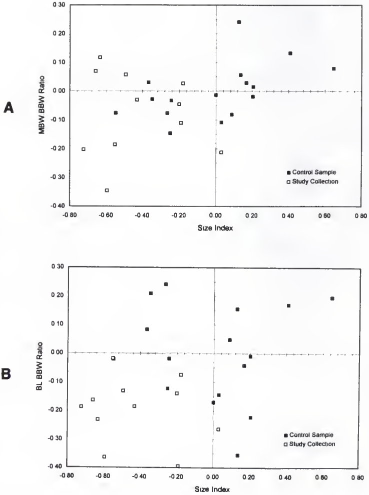


Figure 71. Bivariate relationship between tool size and resharpening for Levy hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio

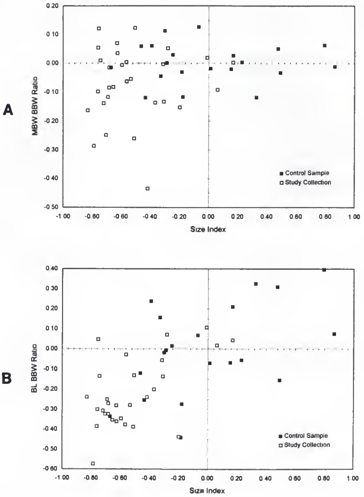


Figure 72. Bivariate relationship between tool size and resharpening for Marion hafted bifaces. a) mid-blade width to basal-blade width ratio, b) blade length to basal-blade width ratio.

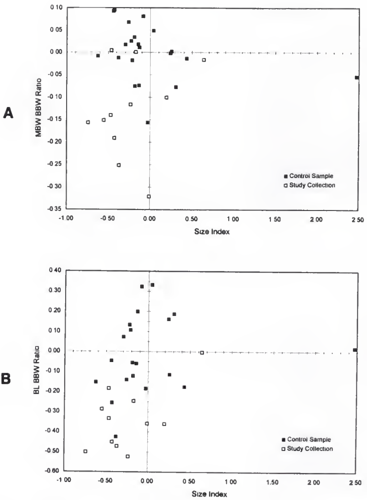


Figure 73. Bivariate relationship between tool size and resharpening for Newnan hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

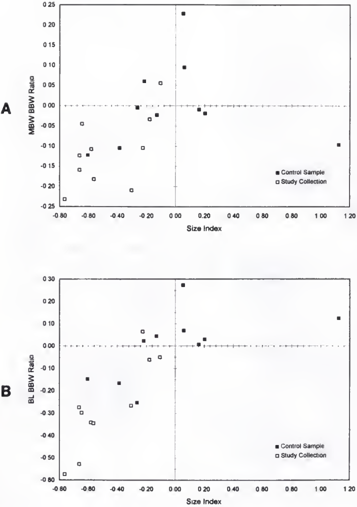


Figure 74. Bivariate relationship between tool size and resharpening for Putnam hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

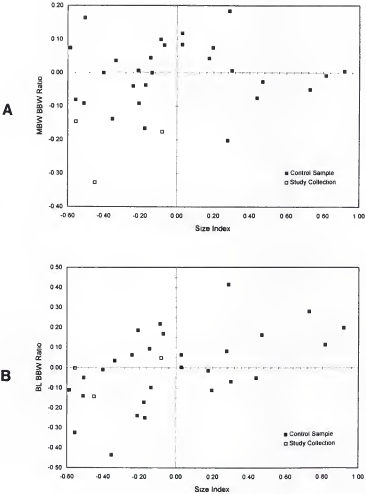


Figure 75. Bivariate relationship between tool size and resharpening for Culbreath hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

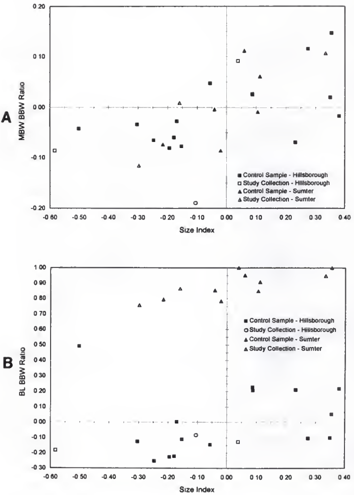


Figure 76. Bivariate relationship between tool size and resharpening for Hillsborough and Sumter hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

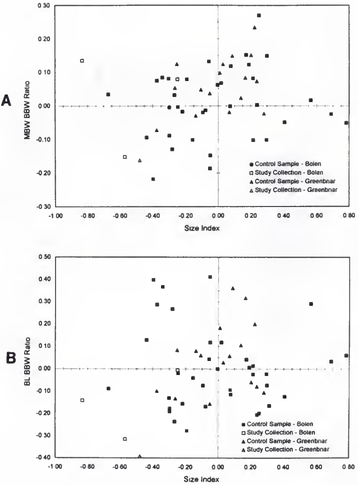


Figure 77. Bivariate relationship between tool size and resharpening for Bolen and Greenbriar hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

margin resharpening. The two Hillsborough points exhibit completely different resharpening patterns. One possesses a low MBW:BBW ratio and a moderately low BL:BBW ratio while the second possesses a low BL:BBW ratio and only a moderately low MBW:BBW ratio.

The only Archaic hafted-biface types that do not conform to these patterns are the Sumter points and several stemmed points that have been classified as generic Florida Archaic Stemmed points. Although many of the individual specimens are smaller than the control-sample means for these types, the MBW:BBW and BL:BBW ratios are typically larger than the control-sample means. Sumter points exhibit very little evidence for either distal or lateral resharpening with only one specimen exhibiting a lower-than-average MBW:BBW ratio (Figure 76). Among the Florida Archaic Stemmed points, none have MBW:BBW ratios that are below the control-sample mean and only two have BL:BBW ratios that are lower than average (Figure 78).

These patterns also are exhibited, albeit to a lesser degree, by the post-Archaic hafted bifaces (Figures 79-83). Again, most specimens are located on the left side of the bivariate graphs, although there appears to be more variability in the post-Archaic study collection than is exhibited by the Archaic types. The number of specimens located in the lower right quadrant in Figure 79 may be artificially inflated by the presence of Columbia and Taylor projectile points. The basal configurations of these hafted bifaces are very similar (cf. Bullen 1975:19, 20; Robinson 1979:14, 15). In all likelihood, the Taylor point represents an end product in the overall biface-reduction sequence of a Columbia point, a sequence that includes rejuvenation and resharpening as well as initial production (cf. Flenniken 1985; Tesar 1994). If the Taylor and Columbia points are grouped together as examples of two ends of a common reduction continuum, and standardized BL:BBW ratio values are calculated on the basis of a combined group mean, then all of the Taylor points, including those in the control sample, fall into the lower left quadrant while most of the Columbia points fall into the upper right quadrant (Figure 80b). Significantly, there is no similar pattern when standardized MBW:BBW ratios are recalculated on the

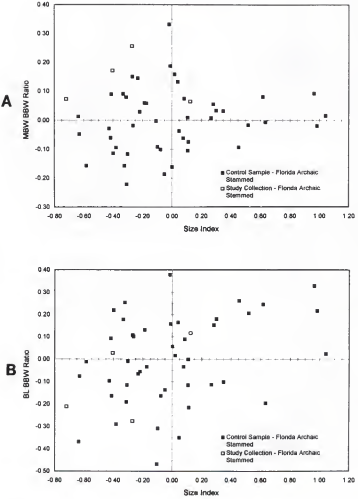


Figure 78 Bivariate relationship between tool size and resharpening for Florida Archaic Stemmed hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

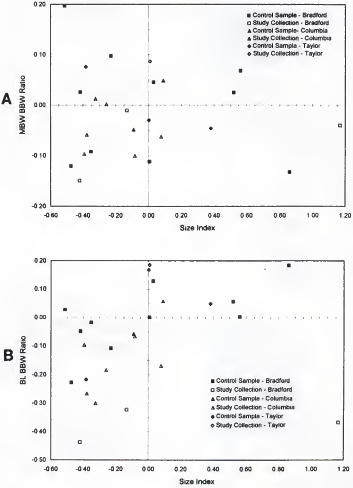


Figure 79 Bivariate relationship between tool size and resharpening for Bradford, Columbia, and Taylor hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

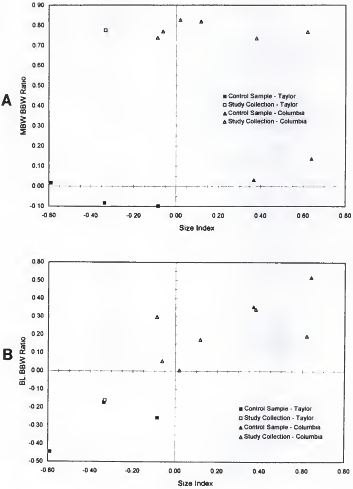


Figure 80. Bivariate relationship between tool size and resharpening for Columbia and Taylor hafted bifaces using a combined group mean: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

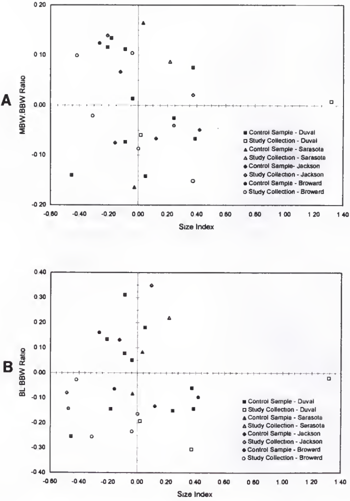


Figure 81 Bivariate relationship between tool size and resharpening for Duval, Sarasota, Jackson, and Broward hafted bifaces: a) mid-blade width to basal-blade width ratio, b) blade length to basal-blade width ratio.

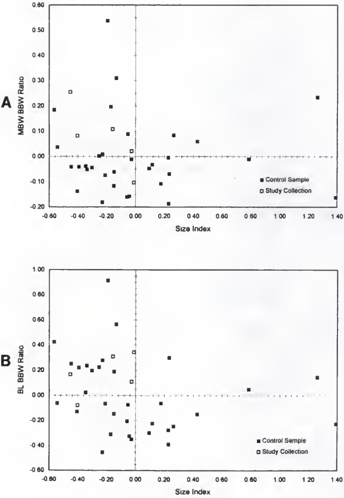


Figure 82. Bivariate relationship between tool size and resharpening for Hernando hafted bifaces: a) mid-blade width to basal-blade width ratio; b) blade length to basal-blade width ratio.

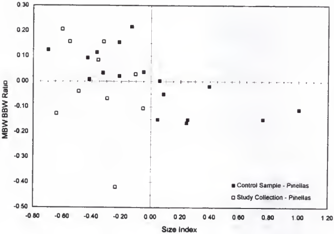


Figure 83. Bivariate relationship between tool size and mid-blade width to basal-blade width ratio for Pinellas hafted bifaces.

basis of a combined group mean (Figure 80a), which suggests that lateral-margin resharpening of these points was not extensive.

Hernando projectile points in the study collection, while smaller than average in overall size, do not exhibit either excessive lateral or distal resharpening (Figure 82), as indicated by the fact that most specimens fall into the upper right quadrant for both ratios. This is clearly a different pattern than that exhibited by the other post-Archaic hafted bifaces (cf. Figures 79 and 81). Visual examination of individual Hernando specimens does indicate minor distal retouch on some specimens and all but two Hernando points exhibit impact-related damage such as distal fractures, haft snaps, blade-corner fractures, and transverse blade fractures (cf. Flenniken 1985; Odell and Cowan 1986), with many of these fracture types occurring in combination. Use-related edge damage on Hernando points also is minimal and is usually restricted to lateral margins near the distal ends of the artifacts These observations suggest that Hernando points were used primarily as projectiles, either as atlatl darts or arrowheads (cf. Austin and Ste. Claire 1982 187-190; Ste Claire 1996). Pinellas points also exhibit little in the way of lateral-margin resharpening with most specimens positioned above the control-sample mean (Figure 83). With one exception, the specimens that possess MBW.BBW ratios below the control-sample mean are clustered within 10 percent of the mean.

Although the sizes of Pinellas projectile points from the study area are generally smaller than those from chert-rich areas (see discussion above), it was not possible to determine if this was due to smaller core size or distal resharpening using the BL:BBW method because of the difficulty in consistently determining true blade lengths on these triangular, stemless projectiles. Many specimens do exhibit distal impact fractures, consistent with their presumed function as arrow points; however, some also exhibit use wear that indicates use as perforators or drills. Visual examination of the Pinellas points in the study collection indicates that distal resharpening was not common despite the presence of distal damage. Perhaps the small sizes of the blanks necessary to make these implements coupled with the comparatively low-cost technology associated with their manufacture made efforts to refurbish damaged implements less of a concern than for larger bifaces

Other tools. The presence of edge rejuvenation on non-biface tools exhibited some variation between Archaic and post-Archaic assemblages, with the ratio of retouched to unretouched tools (R:U) slightly higher among post-Archaic assemblages in both the Peace River and Kissimmee regions (Tables 56 and 57). Even more dramatic are the high R:U ratios for Pineland (8LL33, 36, 37) and Yat Kitischee (8PI1753), both coastal habitation sites Interestingly, the R.U ratio at Fort Center (8GL13) is relatively low (.51); however, this is due to the large numbers of unretouched flake tools at all intrasite components except Mound A where the ratio of retouched to unretouched tools exceeds those at Pineland and Yat Kitischee (Table 58).

When the R:U ratios from the study area are compared to Archaic and post-Archaic sites in chert-rich areas, significant differences are apparent (Tables 56 and 57). The five Archaic sites for

Table 56. Ratios of retouched to unretouched tools (R:U) for Archaic and post-Archaic assemblages

Assemblages	Retouched Tools[a]	Unretouched Tools	R:U Ratio	References
Archaic Assemblages				
8HG18	1	2	.50	This study
8HG20	2	5	.40	This study
8HG27	0	0	.00	This study
8HG34	0	0	.00	This study
8HG35	0	4	.00[b]	This study
8HG51	5	12	.42	This study
8HG678	2	3	.67	This study
8HG767	2	1	2.00	Janus Research 1996a; This study
8HR68	7	9	.78	Janus Research 1995b; This study
8HR71	2	9	.78	Janus Research 1995b; This study
8HR92	6	12	.50	Janus Research 1995b; This study
8HI473	30	221	.14	Chance 1982: Tables IV, VI, VIII; Chance and Misner 1984:Table 29
8HI476A	66	319	.21	Chance 1983a
8HI557	11	90	.12	Austin and Ste. Claire 1982:82
8HI559	1	7	.14	Austin and Ste. Claire 1982:58
Wells	4	7	.57	This study
Post-Archaic Assemblages				
8GL13	22[c]	43	.51	This study
8HG18	4	3	1.33	This study
8HG20	4	8	.50	This study

Table 56 (Continued).

Assemblages	Retouched Tools[a]	Unretouched Tools	R.U Ratio	References
8HG27	5	6	83	This study
8HG34	0	1	.00[b]	This study
8HG665	0	2	.00[b]	This study
8HG675	0	0	.00	This study
8HG678	3	5	.60	This study
8HR44	0	5	.00[b]	This study
8HR48	6	3	2.00	This study
8LL33, 36, 37	11	11	1.00	Austin 1995a: Table 6; This study
8PI1753	22	22	1.00	Austin 1995b: Table 10.19;This study
8PO1685	0	1	.00[b]	This study
8HI471	6	96	.06	Austin 1982:113
8HI556	12	129	.09	Austin and Ste. Claire 1982:146, Tables 21-22

[a] Consists of unifaces, microliths, and modified flakes.

[b] Value of .00 is used because division by zero is not possible.

[c] Includes one cobble fragment that has been bifacially worked along one margin.

which reliable data exist are from Hillsborough County: a quarry site (8HI473), three residential base camps (8HI473, 8HI557, and the Wells site), and a short-term campsite (8HI559). Examination of the individual R:U ratios for these sites indicates a high degree of similarity among them, and in all cases they are much lower than the composite Archaic assemblages from the Peace River and Kissimmee regions. The post-Archaic comparative sample consists of a lithic workshop (8HI556), a logistic campsite (8HI471), and a habitation site (8PI1753). The ratios for the first two are the lowest exhibited by any of the Archaic or post-Archaic assemblages, while the ratio from Yat Kitischee (8PI1753) is

Table 57. Comparison of ratios of retouched (R) to unretouched (U) tools for composite Archaic and post-Archaic assemblages by geographic region.

Regions/Assemblages	Retouched Tools[a]	Unretouched Tools	R:U Ratio
Archaic Assemblages			
Kissimmee Region	12	27	.44
Peace River Region	15	30	.50
Hillsborough River Region, Non-quarry sites	82	423	.19
8HI473, quarry site	30	221	.14
Post-Archaic Assemblages			
Kissimmee Region	16	26	.62
Peace River Region	6	8	.75
8GL13	22[b]	43	.51
8LL33, 36, 37	11	11	1.00
8PI1753, habitation site	22	22	1.00
8HI471, logistic campsite	6	96	.06
8HI556, lithic workshop	12	129	.09

[a] Consists of unifaces, microliths, and modified flakes.
[b] Includes one cobble fragment that has been bifacially worked along one margin.

Table 58 Comparison of ratios of retouched (R) to unretouched (U) tools between intrasite components at Fort Center (8GL13).

Regions/Assemblages	Retouched Tools[a]	Unretouched Tools	R:U Ratio
Mound A	13[b]	9	1.44
Other Proveniences	9	34	.26
Totals	22	43	.51

[a] Consists of unifaces, microliths, and modified flakes.
[b] Includes one cobble fragment that has been bifacially worked along one margin.

among the highest. The ratios for post-Archaic sites from the Peace River and Kissimmee regions lie closer to the Yat Kitischee ratio than either 8HI471 or 8HI556.

Table 59 presents the results of pair-wise chi-square tests of independence comparing the frequencies of unretouched and retouched tools in Archaic and post-Archaic assemblages by geographic region. This series of tests indicates that significant differences exist between the composite Archaic and post-Archaic assemblages from the study area and those located in chert-rich areas farther north. Even though the post-Archaic assemblages from the study area possess higher R:U ratios than the Archaic assemblages, these are not statistically significant. Finally, there are no significant differences between the composite Archaic and post-Archaic assemblages from chert-rich areas, although it should be noted that Yat Kitischee (8PI1753) possesses a substantially higher R:U ratio than either of the other two post-Archaic sites included in this composite assemblage.

Summary. These data indicate that both Archaic and post-Archaic populations inhabiting the study area attempted to economize their lithic materials by practicing more intensive forms of tool edge rejuvenation when compared to assemblages in chert-rich areas; however, the degree to which tool maintenance was practiced varies temporally. Among the Archaic hafted bifaces both lateral and distal resharpening was common and often pronounced. Although similar forms of tool maintenance are observable on post-Archaic hafted bifaces, edge rejuvenation is less common and, where it does occur, it is much less pronounced than on the Archaic period specimens. Furthermore, of the two types of tool maintenance, distal resharpening seems to have been practiced more commonly on post-Archaic bifaces than lateral resharpening.

The attempt to conserve raw materials extended to flake tools and microliths as well. The ratios of retouched to unretouched tools in both the Archaic and post-Archaic assemblages are significantly higher than ratios from contemporaneous assemblages in chert-rich regions. Temporally, there is a slight tendency for post-Archaic sites in the study area to have higher R:U ratios than Archaic sites.

Table 59. Results of pair-wise chi-square tests of independence comparing the frequencies of retouched and unretouched tools among Archaic and post-Archaic assemblages. Bold entries indicate significant differences ($p \leq .05$).

Assemblages	KR Arch	PR Arch	HR Arch	KR PArch	PR PArch	8GL13	8LL33, 36,37	H/P PArch
Kissimmee Region Archaic	---	X^2obs = .063 $df = 1$ $p = .802$	**X^2obs = 7.171** **$df = 1$** **$p = .007$**	X^2obs = .480 $df = 1$ $p = .489$	X^2obs = .671 $df = 1$ $p = .413$	X^2obs = .047 $df = 1$ $p = .829$	X^2obs = 2.215 $df = 1$ $p = .137$	**X^2obs = 7.256** **$df = 1$** **$p = .007$**
Peace River Region Archaic		---	**X^2obs = 10.917** **$df = 1$** **$p = .001$**	X^2obs = .215 $df = 1$ $p = .643$	X^2obs = .423 $df = 1$ $p = .516$	X^2obs = .003 $df = 1$ $p = .955$	X^2obs = 1.728 $df = 1$ $p = .189$	**X^2obs = 10.588** **$df = 1$** **$p = .001$**
Hillsborough River Archaic			---	**X^2obs = 16.013** **$df = 1$** **$p = < .0001$**	**X^2obs = 8.330** **$df = 1$** **$p = .004$**	**X^2obs = 15.873** **$df = 1$** **$p = < .0001$**	**X^2obs = 19.884** **$df = 1$** **$p = < .0001$**	X^2obs = .129 $df = 1$ $p = .720$
Kissimmee Region Post-Archaic				---	X^2obs = .100 $df = 1$ $p = .752$	X^2obs = .312 $df = 1$ $p = .577$	X^2obs = .839 $df = 1$ $p = .360$	**X^2obs = 15.139** **$df = 1$** **$p = .0001$**
Peace River Region Post-Archaic					---	X^2obs = .512 $df = 1$ $p = .474$	X^2obs = .175 $df = 1$ $p = .676$	**X^2obs = 8.623** **$df = 1$** **$p = .003$**
8GL13						---	X^2obs = 2.070 $df = 1$ $p = .150$	**X^2obs = 12.985** **$df = 1$** **$p = .0003$**
8LL33,36,37							---	**X^2obs = 19.284** **$df = 1$** **$p = <.0001$**
Hillsborough/ Pinellas Post-Archaic								---

While these differences are not statistically significant, the small sizes of the samples may be a factor. Two post-Archaic sites exhibit very high R:U ratios: Pineland and Yat Kitischee. Fort Center's Mound A also has a high R:U ratio, although the rest of the site possesses a very low ratio. The separation of these three sites from the rest of the post-Archaic assemblages continues the pattern that has been observed in nearly all of the analyses conducted, and reinforces the notion that these sites represent different strategies of raw-material procurement and use than do other post-Archaic sites included in this study.

Tool Use

Intensity of use on stone tools is indicated by the number of functional units that were employed per tool. For this analysis I have included only non-biface tools because of the difficulty of distinguishing between edge damage resulting from use and that resulting from edge preparation on formal tools. Furthermore, since hafted bifaces are curated tools and can be used for multiple tasks, they might be expected to exhibit a higher degree of use intensity regardless of access to chert sources. Expedient flake tools, on the other hand, should exhibit greater use intensity in chert-poor areas since the source of replacement flakes is limited.

Table 60 indicates that there is very little difference between composite Archaic and post-Archaic assemblages from the Peace River and Kissimmee regions. The mean number of functional units employed in these assemblages is well over 4. However, the Fort Center (8GL13), Yat Kitischee (8PI1753), and Pineland (8LL33, 36, 37) assemblages all possess mean values that are less than 4. A student's *t* test (two-tailed) indicates that 8GL13 and 8PI1753 are significantly different from all of the composite assemblages except the post-Archaic assemblage from the Peace River region (Table 61). The Pineland assemblage seems to be intermediate in terms of use intensity; its mean value of 3.95 is

Table 60. Mean data on use intensity of non-biface tools (utilized flakes, modified flakes, unifaces, and microliths) from Archaic and post-Archaic assemblages.

Assemblages	Number of Non-biface Tools[a]	Number of Utilized Edges	Number of Utilized Functional Units
Archaic, Peace River Region	44	2.06	4.82
Archaic, Kissimmee Region	36	1.89	4.50
Post-Archaic, Peace River Region	14	1.93	4.21
Post-Archaic, Kissimmee Region	39	2.21	4.64
8GL13	60[b]	2.02	3.64
8LL33, 36, 37	22	1.95	3.95
8PI1753	45	1.60	3.38

[a] Includes only those tools with observable use-wear.

[b] Includes a cobble fragment that has been bifacially worked and used for chopping.

not significantly different from any of the other assemblages, yet the mean number of utilized tool edges is among the highest.

The only Archaic period site from a chert-rich area with comparable data on use intensity is the Ranch House site (8HI452) where use-wear data on flake tools were recorded by "employable units" using a polar grid method similar to the one used in this study (cf. Estabrook and Newman 1984:85-86). While these data are not reported consistently for all tools at this site, a total of 55 employable units from 42 flake tools, unifaces, and microliths are reported (Estabrook and Newman 1984:183, 211, 236, 239, 278) allowing for a mean value of 1.3 to be calculated. This is significantly lower than the mean values calculated for all of the assemblages included in Table 60.

Summary. The major distinction between sites in the study area appears to be geographic and perhaps functional rather than temporal. The three definite habitation sites -- Fort Center, Pineland,

Table 61. Results of Student's t tests (two-tailed) comparing mean numbers of utilized functional units between assemblages. Bold entries indicate significant differences ($p \leq .05$).

Assemblages	KR Arch	PR Arch	KR PArch	PR PArch	8GL13	8LL33, 36,37	8PI1753
Kissimmee Region, Archaic	---	$t = .82$ $df = 78$ $p = .414$	$t = -.33$ $df = 73$ $p = .742$	$t = .52$ $df = 48$ $p = .602$	**$t = 2.20$** **$df = 94$** **$p = .03$**	$t = -1.10$ $df = 56$ $p = .268$	**$t = 3.17$** **$df = 79$** **$p = .002$**
Peace River Region, Archaic		---	$t = .43$ $df = 81$ $p = .671$	$t = 1.08$ $df = 56$ $p = .283$	**$t = 3.16$** **$df = 102$** **$p = .002$**	$t = -1.77$ $df = 64$ $p = .082$	**$t = 4.10$** **$df = 87$** **$p = < .0001$**
Kissimmee Region, Post-Archaic			---	$t = -.69$ $df = 51$ $p = .494$	**$t = 2.45$** **$df = 97$** **$p = .016$**	$t = -1.28$ $df = 59$ $p = .207$	**$t = 3.27$** **$df = 82$** **$p = .002$**
Peace River Region, Post-Archaic				---	$t = .97$ $df = 72$ $p = .336$	$t = -.38$ $df = 34$ $p = .682$	$t = 1.68$ $df = 57$ $p = .098$
8GL13					---	$t = .58$ $df = 80$ $p = .565$	$t = .91$ $df = 103$ $p = .366$
8LL33, 36, 37						---	$t = 1.30$ $df = 65$ $p = .199$
8PI1753							---

and Yat Kitischee -- all have assemblages that indicate slightly less intense use of non-biface tools while both Archaic and post-Archaic sites in the Peace River and Kissimmee regions have assemblages with significantly higher mean values for the number of functional units employed on non-biface tools, indicating more intensive use of limited raw materials. This distinction is illustrated in Figure 84 which is a bivariate graph that plots the number of utilized functional units versus the number of utilized tool edges. The composite Archaic and post-Archaic assemblages from the Peace River and Kissimmee regions are clustered together near the upper right corner while Fort Center, Yat Kitischee, and Pineland are separated from these sites. Of these three, Yat Kitischee is located closest to chert sources and Fort Center was a locus for the import and stockpiling of lithic material via trade. Thus, the lower values for both variables at these two sites may be the result of having somewhat greater access to lithic raw materials than the other post-Archaic sites in the study. Interestingly, the composite post-Archaic assemblage from sites in the Peace River valley displays the lowest mean value for the number of functional units and the second lowest value for the number of utilized edges of any of the composite assemblages. While the differences are not great, these low values are interpretable in light of having access to a nearby chert resource.

Although greater relative access to raw materials may explain the slightly lower values for the post-Archaic assemblages, the only comparable data available for post-Archaic assemblages from a chert-rich area are those from Yat Kitischee. While the mean values for both variables at this site were the lowest of all the post-Archaic assemblages, they were not significantly different from either Fort Center or Pineland. Without additional comparative data, it is not possible to say if the lower values at these sites indicate less concern with raw-material conservation. My hunch is that they do not, but that access to alternative raw materials (i e., shell and sharks' teeth) simply made the need for intensive use of lithic materials less acute.

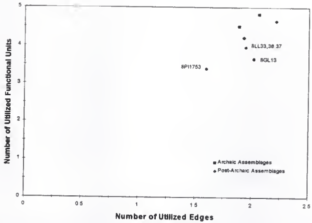


Figure 84. Bivariate plot of mean number of utilized tool edges versus mean number of functional units for Archaic and post-Archaic assemblages.

Intensity of Raw-Material Use

Before concluding this section, one other aspect of lithic economizing needs to be examined: the intensity of raw-material use. Where the supply of lithic raw materials is limited, there should be evidence of more intensive use of all available stone. If intensive raw-material use was practiced, then the ratio of flakes to flake tools (F:FT) should be low as a result of people maximizing their use of available flakes as potential tools. In Table 62, data are presented on the number of flakes and flake tools in the various Archaic and post-Archaic assemblages in the study area, with comparable data presented for contemporaneous assemblages in chert-rich areas of Hillsborough and Pinellas counties. Composite data separated by geographic region are presented in Table 63. It should be noted that I have included microliths in the flake-tool category because this tool type was manufactured from small flakes that were either struck from cores or scavenged from available waste debris.

Table 62. Ratios of flakes (F) to flake tools (FT) for Archaic and post-Archaic assemblages.

Assemblages	Flakes	Flake Tools[a]	F:FT Ratio	References
Archaic Assemblages				
8HG18	37	3	12.33	This study
8HG20	21	5	4.20	This study
8HG27	3	0	.00[b]	This study
8HG34	27	0	.00[b]	This study
8HG35	52	4	13.00	This study
8HG51	565	17	33.24	This study
8HG678	44	5	8.80	This study
8HG767	40	3	13.33	This study
8HI473	113,117	251	450.67	Chance 1982; Chance and Misner 1984
8HI476A	33,153	337	98.38	Chance 1983a
8HI557[e]	7123	99	71.95	Austin and Ste. Claire 1982:82
8HI559[f]	623	8	77.88	Austin and Ste. Claire 1982:58
8HR68	255	14	18.21	This study
8HR71	247	11	22.45	This study
8HR92	477	18	26.50	This study
Wells	501	10	50.10	This study
Post-Archaic Assemblages				
8GL13	606	63	9.62	This study
8HG18	84	7	12.00	This study
8HG20	104	9	11.56	This study
8HG27	62	11	5.64	This study
8HG34	6	1	6.00	This study
8HG665	12	2	6.00	This study
8HG675	16	0	.00[b]	This study

Table 62 (Continued).

Assemblages	Flakes	Flake Tools[a]	F:FT Ratio	References
8HG678	72	8	9.00	This study
8HI471	1761	100	17.61	Austin 1982:113
8HI556	10,594	141	75.13	Austin and Ste. Claire 1982:146, Tables 21-22.
8HR44	168	5	33.60	This study
8HR48	175	9	19.44	This study
8LL33, 36, 37	77	22	3.50	Austin 1995a:Table 37; This study
8PI1753	326	52	6.27	Austin 1995b; This study
8PO1685	10	1	10.00	This study

[a] Consists of utilized flakes, modified flakes, and microliths.
[b] Value of .00 is used because division by zero is not possible.

These data indicate that Archaic and post-Archaic assemblages in the study area have lower F:FT ratios than do comparable assemblages in chert-rich regions. While differences between the Kissimmee region and Peace River regions are minimal for Archaic assemblages, post-Archaic assemblages in the Peace River region have higher F:FT ratios than any of the other south Florida post-Archaic assemblages. Moreover, differences between Archaic and post-Archaic assemblages within the study area are pronounced, especially for areas outside of the Peace River valley. A series of pair-wise chi-square tests of independence comparing the frequencies of flakes and flake tools in each of the various regional assemblages indicates that these observed differences are statistically significant (Table 64).

Three of the sites with the lowest F:FT ratios are Fort Center, Pineland, and Yat Kitischee, with Pineland having the lowest ratio of the three. This is no doubt due to limited access to lithic outcrops, and while it is at variance with the data on tool-use intensity described above, it is consistent with the

Table 63. Comparison of flakes (F) to flake tool (FT) ratios for composite Archaic and post-Archaic assemblages by geographic region.

Assemblages/Regions	Flakes	Flake Tools[a]	F:FT Ratio
Archaic Assemblages			
Kissimmee Region	789	37	21.32
Peace River Region	1006	43	23.39
Hillsborough River Region, Non-quarry sites	41,400	454	91.19
8HI473, quarry site	113,117	256	441.86
Post-Archaic Assemblages			
Kissimmee Region	366	39	9.39
Peace River Region	343	14	24.50
8GL13	606	63	9.62
8LL33, 36, 37	77	22	3.50
8PI1753, habitation site	326	52	6.27
8HI471, logistic campsite	1761	100	17.61
8HI556, lithic workshop	10,594	141	75.13

[a] Consists of utilized flakes, modified flakes, and microliths.

high ratios of retouched to unretouched tools in these assemblages. The comparatively high F:FT ratio for Fort Center is somewhat surprising given its distance from a chert source, but the ratio is strongly influenced by the large number of waste flakes associated with the reduction of the chert cobbles at Mound A which account for 42.57 percent of the total flake assemblage at this site. Moreover, access to this stockpile of lithic material may have been limited to craft specialists who resided at Mound A, as discussed above. Thus, we might expect that the intensity of raw-material use would be greater in areas of the site where immediate access to stone was limited. And in fact, the ratio of flakes to flake tools at Mound A is 394:21 or 18.76 while the same ratio for the rest of the site is only 212:42 or 5.05.

Table 64. Results of pair-wise chi-square tests of independence comparing the frequencies of flakes and flake tools between regional Archaic and post-Archaic assemblages. Bold entries indicate significant differences ($p \leq .05$).

Assemblages/ Regions	KR Arch	PR Arch	HR Arch	8HI473	KR PArch	PR PArch	SFla PArch	8PI1753	HR PArch
Kissimmee Region Archaic	---	X^2obs = .164 df = 1 p = .686	**X^2obs =** **82.085** **df = 1** **p = <.0001**	**X^2obs =** **530.791** **df = 1** **p = <.0001**	**X^2obs =** **12.444** **df = 1** **p = .0004**	X^2obs = .188 df = 1 p = .665	**X^2obs =** **24.440** **df = 1** **p = <.0001**	**X^2obs =** **32.604** **df = 1** **p = <.0001**	**X^2obs =** **25.166** **df = 1** **p = <.0001**
Peace River Region Archaic		---	**X^2obs =** **81.213** **df = 1** **p = <.0001**	**X^2obs =** **548.056** **df = 1** **p = <.0001**	**X^2obs =** **16.794** **df = 1** **p = <.0001**	X^2obs = .022 df = 1 p = .883	**X^2obs =** **32.881** **df = 1** **p =<.0001**	**X^2obs =** **41.705** **df = 1** **p = <.0001**	**X^2obs =** **22.702** **df = 1** **p = <.0001**
Hillsborough River Region Archaic			---	**X^2obs =** **495.318** **df = 1** **p = <.0001**	**X^2obs =** **254.013** **df = 1** **p = <.0001**	**X^2obs =** **25.982** **df = 1** **p = <.0001**	**X^2obs =** **601.946** **df = 1** **p = <.0001**	**X^2obs =** **508.155** **df = 1** **p = <.0001**	**X^2obs =** **54.752** **df = 1** **p = <.0001**
8HI473, quarry site				---	**X^2obs =** **1270.988** **df = 1** **p = <.0001**	**X^2obs =** **186.414** **df = 1** **p =<.0001**	**X^2obs =** **2802.712** **df = 1** **p =<.0001**	**X^2obs =** **2363.281** **df = 1** **p = <.0001**	**X^2obs =** **764.447** **df = 1** **p = <.0001**
Kissimmee Region Post-Archaic					---	**X^2obs =** **9.553** **df = 1** **p = .002**	X^2obs = .580 df = 1 p = .446	X^2obs = 3.242 df = 1 p = .072	**X^2obs =** **110.868** **df = 1** **p = <.0001**
Peace River Region Post-Archaic						---	**X^2obs =** **15.508** **df = 1** **p = <.0001**	**X^2obs =** **21.729** **df = 1** **p = <.0001**	**X^2obs =** **7.255** **df = 1** **p = .007**

Table 64 (Continued).

Assemblages/ Regions	KR Arch	PR Arch	HR Arch	8HI473	KR PArch	PR PArch	SFla PArch	8PI1753	HR PArch
South Florida[a] Post-Archaic							---	X^2obs = 1.740 $df = 1$ $p = .187$	**X^2obs = 254.895 $df = 1$ $p = < .0001$**
8PI1753								---	**X^2obs = 233.197 $df = 1$ $p = < .0001$**
Hillsborough River Post-Archaic									---

[a] Includes 8GL13 and 8LL33, 36, 37.

Thus, the pattern of intrasite use of raw material at Fort Center appears to have been influenced by the same factors that underlie the intensity of use at the regional scale.

Minimization of Production Costs

By reducing the handling costs associated with processing raw materials that are expensive to obtain, it is possible to offset the high costs of procurement. The manufacture and use of expedient flake tools are low-cost alternatives to the production of formal, shaped tools that require an increased expenditure of labor to produce and maintain. This type of low-cost strategy should be observable archaeologically by a high incidence of casual, amorphous cores and bipolar cores in lithic assemblages where expedient tool production and use predominated. Table 65 provides data on the core types represented in the various lithic assemblages from the study area. Also included in these tabulations are several hammerstones that display evidence of having been used as cores either before or after their use as hammers.

Only one single-platform core with evidence of systematic flake removals is represented in Table 65, and it is from a post-Archaic site, 8HR48 (Figure 85a). This core is made from chert derived from the Hillsborough River Quarry Cluster. Three additional single-platform cores were observed in surface-collected assemblages: two from the Beck site (8HG679) and one from Coral Point (8HG49), both located near Lake June-in-Winter on the Lake Wales Ridge. All three of these cores are illustrated in Figure 85. The largest is 35.25 x 34 95 x 20.70 mm. Two are made from cherts derived from the Hillsborough River Quarry Cluster (Bay Bottom and Type 4 chert) and the third is a possible Peace River Quarry Cluster chert. Because it is not possible to assign these cores with any certainty to a specific cultural/temporal period, they have not been included in Table 65. However, hafted bifaces from both sites are dominated by Archaic types (see Appendices D and E), and my guess is that the cores also are Archaic in origin.

Table 65. Core types in Archaic and post-Archaic assemblages.

Site	Pyramidal, Single Platform	Amorphous, Single Platform	Amorphous, Multiple Platforms	Bifacial	Bipolar	Indeterminate
Archaic Assemblages						
8HG51						1
8HG68				2[a]		
8HR71						
8HR92			1	2[b]		
Totals			1	4		1
Post-Archaic Assemblages						
8GL13[c]		4	6	2	76	6
8HG18				1[b]		
8HG27			1			
8HR44			1			
8HR48	1		1			
8LL33, 36, 37[c]		1	4[d]			
8PI1753[c]		1	6		7	1
Totals	1	6	19	3	83	7

[a] One bifacial core exhibits evidence of having been rested on an anvil flake removal.

[b] Bifacial cores exhibit evidence of having been rested on an anvil during flake removal.

[c] Totals include some hammerstones that exhibit evidence of having been used also as cores.

[d] One (1) amorphous core exhibits evidence of having been rested on an anvil.

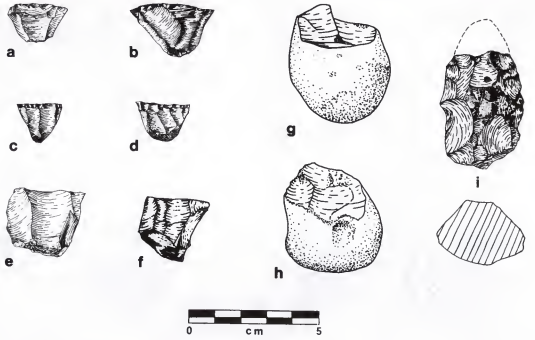


Figure 85. Examples of cores: a-d) single-platform, pyramidal cores; e-f) amorphous cores; g-h) bipolar cores; i) bifacial core. Proveniences a) 8HR48. b) 8HG679; c-d) 8HG49; e) 8HG18; f) 8PI1753; g-h) 8GL13; i) 8HR68.

Six other small cores exhibit single platforms, all from post-Archaic assemblages. Their shapes, and the sizes and orientation of the flake scars, do not suggest systematic removal. They are probably best characterized as amorphous cores or core fragments that have not been intensively reduced. In comparison, the three surface-collected cores are pyramid shaped, a result of intensive and progressive removal of flakes from a single platform. While the size and shape of the core from 8HR48 are similar to those in the surface-collected assemblages, flake removals do not appear as systematic. It is possible that this specimen also is an amorphous core that has not been intensively reduced and by coincidence has a pyramid shape.

The most common core type in the post-Archaic assemblages is the multiplatform, amorphous core (Figure 85e-f) with six of the seven assemblages containing at least one example. The most common in terms of total frequency is the bipolar core (Figures 56b-d and 85g-h). This is due to the large number of chert cobbles (76) that were reduced or tested using bipolar percussion at Fort Center (8GL13). Amorphous cores exhibiting evidence of having been rested on an anvil during flake removal are present in two of the post-Archaic assemblages and bipolar flakes are present in three assemblages: 8GL13 (16), 8LL33, 36, 37 (3), and 8PI1753 (42).

Because the number of cores from confirmed Archaic assemblages is small, it is difficult to identify any trends in the data; however, of the five cores in these assemblages, four are bifacial (e.g., Figure 85i). No single-platform cores are present nor are any bipolar cores, although two small, bifacial cores exhibit battering on opposing edges suggesting that they may have been set on an anvil when receiving detachment blows. The only other evidence for possible bipolar- core reduction is a single bipolar flake in the Archaic period component at the Gaging Station site (8HG18).

Summary. While the dominance of bifacial cores in the Archaic assemblages may be an artificial pattern resulting from small sample size, their use is consistent with the type of portable, multi-functional tool kit that is typically associated with residentially mobile hunter-gatherers (Kelly 1988).

The widespread use of amorphous-core technology during the post-Archaic is a stronger pattern that appears to be at odds with the expectation of lithic economizing, but is consistent with those of minimizing production costs. While less efficient than a prepared-core technology, amorphous-core reduction is less costly in terms of the time necessary to learn and master the technique as well as in actual production time (Johnson 1987:2; Parry and Kelly 1987:299). My own limited experiments in the reduction of small cores (see Chapter 8) indicated that the time necessary to produce four or five usable flakes from a small, amorphous core was typically less than two minutes. Compare this with 20-45 minutes for manufacturing a single hafted biface and it is clear that expedient, casual core reduction represents a significant reduction in handling costs.

Reduction of Lithic Demand

Reducing the demand for a resource can be accomplished in two ways. The first is to limit its consumption; in other words, to practice economizing measures. As discussed above, there is evidence to suggest that economizing of lithic raw materials was practiced during both the Archaic and post-Archaic periods. A second way to reduce demand for an expensive commodity is to substitute a cheaper alternative. In the case of prehistoric technologies, where durable raw materials were necessary for the manufacture of utilitarian implements, a suitable substitute for siliceous stone would have been marine shell, sharks' teeth, bone, antler, or wood. Since the last three materials require that tools made from durable raw materials be used to procure and work them into functional implements, and since their preservation in the archaeological record is incomplete, I will not consider them further in this analysis. Marine shell and sharks' teeth, however, are abundant at many coastal and some interior sites, and were widely and intensively used as a replacement for stone.

In the following section I first present data that illustrate a quantitative reduction in the use of lithic raw materials through time. I then examine the economic factors that account for the substitution of alternative raw materials such as shell and sharks' teeth for stone.

Quantitative Decline in Lithic Demand

Quantitative decline in the demand for lithic resources is demonstrated by the data in Tables 66 and 67 which compare the density of lithic artifacts per cubic meter of excavated soil between three cultural-temporal periods. This decline in demand is graphically displayed in Figure 86. The data are from sites located within the Kissimmee region and only lithic artifacts from excavated units are included in the density calculations. The presence of sand-and-fiber-tempered pottery in excavated levels/strata was used to identify early Belle Glade (i.e., Period I or Belle Glade I) deposits. Sites located in the Kissimmee River valley (i.e., 8HG18, 8HG20, 8HG27, 8HG34, 8HG35, 8HG665, and 8PO1685) are included in the Kissimmee River assemblage while sites on the Lake Wales Ridge and near Lake Istokpoga (i.e., 8HG51, 8HG675, and 8HG678) are included in the Lake Wales Ridge assemblage. Volume was calculated using only those excavated levels that contained lithic artifacts.

The general trend is similar in both assemblages. Lithic density is moderate during the preceramic Archaic period and increases during the post-Archaic Belle Glade I period. While this increase is more dramatic in the river valley than along the Lake Wales Ridge, it is a pattern that is repeated at several of the sites included in this study; in other words, the increases are not due to one or two sites with large numbers of artifacts associated with sand-and-fiber- tempered pottery affecting the average density for this component. The increase in lithic artifact density during the initial phases of the post-Archaic may be a reflection of increasingly intensive habitation, slightly larger populations, longer duration of stay, or all of these. Whatever the reason, the demand for lithics remained high. However, assemblages from both areas indicate a decrease in lithic density during the later Belle Glade periods. Given the larger, denser midden deposits associated with these later occupations and the reduction in lithic density in excavated strata, the likeliest explanation for this decrease is reduced demand as a result of a restriction in the procurement range of the sites' inhabitants in combination with the use of alternative raw materials such as shell and sharks' teeth obtained through exchange. A similar decrease in demand is observed in the Peace River valley (Table 68), although the trend is not

Table 66 Lithic density calculations for Archaic and post-Archaic components in the Kissimmee region.

Site/Component	Volume of Excavated Soil[a]	Lithic Artifacts[b]	Lithic Artifacts Per Cubic Meter
Archaic Components			
8HG18	2.03	40	19.75
8HG20	1.65	29	17.58
8HG27	.40	3	7.50
8HG34	10.80	27	2.25
8HG35	2.00	38	19.00
8HG51	21.60	469	44.25
8HG678	9.40	56	5.96
Belle Glade I Components			
8HG18	.40	52	130.00
8HG20	.63	79	126.40
8HG27	1.00	57	57.00
8HG665	.20	9	45.00
8HG678	2.00	41	20.50
Belle Glade II-IV Components			
8HG18	3.00	44	14.67
8HG20	1.03	40	39.02
8HG27	1.40	22	15.71
8HG34	1.80	7	3.89
8HG665	35	9	25.71
8HG675	1.10	17	15.45
8HG678	8.40	51	6.07
8PO1685	.50	9	18.00

[a] Includes only excavated levels that contained lithic artifacts.

[b] Includes only those artifacts recovered from excavated units, i.e., no artifacts from shovel tests, surface collections, or other uncontrolled proveniences.

Table 67. Lithic artifact density by region and cultural components.

Cultural/ Temporal Component	Lithic Density Per Cubic Meter	
	Kissimmee River Valley	Lake Wales Ridge
Archaic	18.11	16.94
Belle Glade I	50.68	20.95
Belle Glade II-IV	8.84	7.16

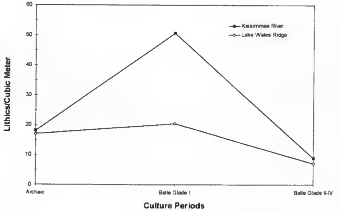


Figure 86. Variation in lithic artifact density by cultural-temporal component, Kissimmee region.

Table 68. Lithic density calculations for Archaic and post-Archaic components in the Peace River region.

Site/Component	Volume of Excavated Soil[a]	Lithic Artifacts[b]	Lithic Artifacts Per Cubic Meter
Archaic Components			
8HR68	6.00	179	29.83
8HR71	5.40	139	25.74
8HR92	3.78	297	78.68
Totals	15.18	615	40.51
Post-Archaic Components			
8HR44	1.60	130	81.25
8HR48	29.60	166	5.61
Totals	31.20	296	9.49

[a] Includes only excavated levels that contained lithic artifacts.

[b] Includes only those artifacts recovered from excavated units, i.e., no artifacts from shovel tests, surface collections, or other uncontrolled proveniences.

as strongly supported because of the small number of sites. For example, the two post-Archaic sites display radically different lithic artifact densities. The high density figure for 8HR44 may be a consequence of the sampling procedure (only one 1 x 2 m excavation unit was excavated at this site) or differences in activities between this site and 8HR48. The local availability of Peace River Quarry Cluster cherts no doubt also is a factor.

Substitutable Resources: Marine Shell and Sharks' Teeth

Unlike stone, the collection of marine shell and sharks' teeth are naturally embedded in the subsistence pursuits of a coastal population. This, perhaps more than geographic proximity or overall abundance, greatly reduces the cost of material acquisition as well as affecting the rate at which these tools will be replaced. To the extent that these raw materials could be substituted for stone in performing specific functional tasks, then access to these "cheaper" alternatives would have reduced the demand for stone.

This relationship is illustrated by data from two sites, Pineland and Yat Kitischee. The total number of shell tools recovered from Pineland is 754 (Patton n.d.1) while the number from Yat Kitischee is 159 (Austin 1995c:Table 9.1). The ratio of shell to stone tools at Yat Kitischee is 159:74 or 2.15 while at Pineland the ratio is 754:50 or 15.08. (I should note that in this and subsequent comparisons I do not count shell artifacts such as beads, dippers, or cups since these have no functional analogue in the flaked-stone assemblages and so do not represent a fair comparison. Nor do I include shell debitage because of the difficulty of identifying this artifact class among the thousands of pieces of food shell at coastal middens. Since shell debitage is not included, I also do not include unutilized lithic waste flakes or cores. The ratios of shell to stone for all sites discussed are limited to recognized tools and production rejects.) The substitutability of the two resources is illustrated graphically in Figure 87. The raw frequency values for each raw material have been converted to percentages in order to standardize the comparison; however, the ratios between chert and shell remain the same. Figure 87 shows the effect on the proportional mix of raw materials that results from an increase in the cost (price) of acquiring stone, which in this case is analogous to search and transport costs (i.e., distance). This shift in preference is denoted in the figure by amount *X*. The shallow indifference curve connecting the two resource mixes (93.78 percent to 6.22 percent for Pineland; 68.24 percent to 31.76 percent for Yat Kitischee) indicates that shell and stone were highly substitutable resources. If they were complimentary resources, then the indifference curve would be more strongly curved and the change in the mixture consumed would be less (Glahe and Lee 1989:113-117; Stephens and Krebs 1986:110-112). From this relationship it can be inferred that the cost of procurement, as measured by distance to resources, was an important factor that influenced prehistoric decision-making regarding the relative dependence on the use of different raw materials.

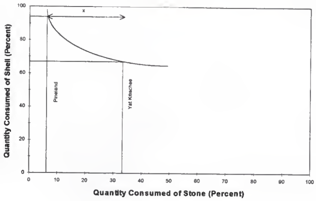


Figure 87. Relative change in the mixture of shell and stone in the technological inventory as the cost of stone increases. At Pineland, where stone is expensive to acquire and shell is inexpensive, the relative abundance of shell is high. At Yat Kitischee, where the cost of acquiring stone is much lower, the relative mix of the two resources is more even. The shallow indifference curve reflects the substitutability of the two resources. The line *X* indicates the change in the resource mix that occurs as a result of the increase in the cost of stone.

Clearly, this comparison is artificial in that the resulting indifference curve is based on data from only two sites and the resource mixes do not include all durable raw materials that were available to native peoples. Nonetheless, it can serve as a first approximation that can be used to predict the potential mixes of shell and stone in other situations. For example, it would be interesting to compare the resource mixes from interior sites such as Fort Center, where both shell and siliceous stone were expensive commodities to obtain, to those from coastal sites such as Pineland and Yat Kitischee. Unfortunately, although Steinen (1982:83-84) indicates that eight shell plummets and "441 shells, *shell tools, and shell fragments" were recovered from Fort Center's mound-pond complex, he provides no information on exactly how many of the 441 shells were classified as tools. The quantitative data presented in his Tables 6.1-6.4 appear to be incomplete since the total number of shell artifacts, which includes artifacts from proveniences other than the mound-pond complex, equals only 68. All of the shell tools that are discussed or illustrated in his report are marine shell and most appear to have been used for heavy-duty woodworking. Steinen's (1982 84, Figure 6.3) functional categories include axes, celts, adzes, gouges, and picks, and most of these were manufactured from large lightning whelk (Busycon sinistrum) or horse conch (Pleuroploca gigantea) shells. Complicating this, however, is the fact that both Steinen (1982:86) and Sears (1982:155, 160) indicate that some of the shells from the mound-pond complex were probably dippers. Sears's map of Mound B indicates a total of 48 shell artifacts, of which 18 were identified as dippers (Sears 1982:Figure 9.12).

The lack of precise frequency data for the shell artifacts at Fort Center makes it difficult to make a valid quantitative comparison between the use of shell and stone. As an exercise, however, we can make a conservative estimate that half of the 441 shell artifacts reported by Steinen represent tools or tool fragments. Given the cost of importing marine shell to the central interior of south Florida, this may not be an unreasonable assumption. If valid, then the ratio of shell tools to stone tools in the mound-pond complex would be 220 to 117, or 1.88, a figure that is more comparable to Yat Kitischee than Pineland. Even if all of the 441 shell artifacts are considered tools, the ratio is only 3.77 (441:117). The low ratio of shell to stone at Fort Center suggests that the costs of acquisition for both raw materials were relatively equal resulting in a more even mix.

It is difficult to make a similar comparison for the Archaic period because of the absence (until recently) of well-documented preceramic Archaic components in coastal areas. Russo's (1991) recent excavation at Horr's Island indicates that marine shell, sharks' teeth, and bone were used almost exclusively as raw materials for tools. Only a few lithic artifacts are reported and all except one chert projectile point were manufactured from sandstone and limestone which were probably available locally. The very low occurrence of non-local siliceous stone at Horr's Island does not appear to be an isolated occurrence in southwest Florida. Milanich et al. (1984.273) report only a single chert projectile point from the Archaic levels at Useppa Island, and Bullen and Bullen (1976:Table 1) report no lithic artifacts from the preceramic Archaic levels at the Palmer site. On the other hand, shell tools are plentiful at both of these sites. When compared to the amount of lithic artifacts at Pineland, it would appear that there was actually an increase in demand for lithic artifacts through time, at least along the southwest coast.

Perhaps the best data illustrating the replacement of stone by shell from Archaic to post-Archaic times comes from two sites in the St. Johns region: Hontoon Island and Groves' Orange Midden. Archaeological deposits at the latter site date almost exclusively to the preceramic Archaic (McGee and Wheeler 1994:342) while Hontoon Island appears to have been occupied from A.D. 0 to 1770 (Purdy 1987a:12). The sites are about 14.5 km apart and both are located approximately 64 km or so from the nearest known chert sources. They are also more than 40 km from the east coast. At Groves' Orange Midden the ratio of shell tools to lithic tools is 16:64 or .25 (Purdy 1994:390; Wheeler and McGee 1994:Table 4) while at Hontoon Island the ratio is 87:74 or 1.18 (Purdy 1987b). Figure 88 illustrates the shift in preference from stone to shell. Note that the indifference curve is shallow reflecting the substitutability of these two resources.

While marine shell may have been an acceptable substitute for many tasks performed by stone tools, such as heavy woodworking, scraping, or some cutting and slicing activities, other tasks may have been better performed by a harder and more durable material. For example, piercing, boring, drilling, grating, and engraving tasks, or the cutting and sawing of particularly hard and dense materials, are not easily accomplished using shell. Sharks' teeth apparently served as an acceptable substitute for some of these tasks, particularly engraving, drilling, and grating (Brown 1994:102-104; Kozuch 1993:31-32); however, the costs and risk associated with capturing and processing sharks would have made this raw material attractive only where the cost of acquiring stone was excessive Larson (1980:82-84), for example, points out the danger of attempting to land a shark in an unstable watercraft, and while

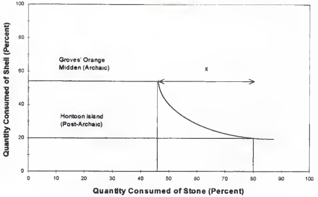


Figure 88. Comparison of the relative change in the mixture of shell and stone in the technological inventories of Archaic (Groves' Orange Midden) and post-Archaic (Hontoon Island) components in the St. Johns region of central Florida. A reduction in demand for stone is indicated during the post-Archaic period with a corresponding increase in the use of shell. The shallow indifference curve reflects the substitutability of the two resources. The line *X* indicates the change in the resource mix between culture periods.

Kozuch's (1993:15-19) review of ethnographic accounts of shark fishing indicates that capturing sharks using traditional technologies and watercraft is possible, there is no denying that a prey that is powerful, elusive, and deadly presents a much greater risk than one that is slow-moving, non-aggressive, and unequipped with razor-sharp teeth. Moreover, while experiments in the use of sharks' teeth as tools have demonstrated that they are useful for a number of tasks (e.g. Brown 1994), there have to my knowledge been no controlled experiments designed to compare the efficiency of different raw materials (e.g., stone versus sharks' teeth) performing similar tasks. Whatever the reasons, the preference for stone over sharks' teeth as a durable raw material is exemplified by the geographic distribution of sites where shark tooth tools are abundant. The vast majority are located in the coastal regions of south Florida and on the Atlantic coast (Kozuch 1993:Appendix A). Data from coastal sites in the central

Gulf coast region indicate that sharks' teeth were rarely used for tools there despite the availability of a variety of shark species. For example, no utilized sharks' teeth were recovered from Yat Kitischee, although shark remains and several unutilized teeth were present in the faunal assemblage (Mitchell 1995; Vojnovski 1995). It is no coincidence that this reduction in the use of shark tooth tools coincides with the geographic distribution and availability of chert outcrops. On the other hand, tools made from sharks' teeth are abundant at both Pineland and Fort Center. Patton (n.d. 2) reports that 19 drilled sharks' teeth were recovered from the former site while Steinen (1982:70-75) describes 174 utilized sharks' teeth from the mound-pond complex at Fort Center (although Kozuch's [1993:23, Table 6] reanalysis indicates that only 72 sharks' teeth show definite signs of human modification and/or use). Shark tooth tools also have been recovered from several of the Kissimmee region post-Archaic components included in this study including the Gaging Station site (8HG18), Bluff Hammock (8HG665), the Blueberry site (8HG678), and the River Ranch Midden (8PO1685) (Austin 1996a).

Figure 89 provides a comparison of the relative preferences for sharks' teeth and chert at Pineland and Fort Center's mound-pond complex using Kozuck's (1993) shark tooth data for the latter site. As might be expected, given the functionally limited role of sharks' teeth in prehistoric technology, the indifference curve connecting the two resource mixes (27.54 percent to 72.46 percent for Pineland; 38.09 percent to 61.91 percent for Fort Center) indicates that sharks' teeth were not as substitutable for stone as shell. This also is indicated by the relatively small change in the mixture of the two resources denoted by X in the figure. Interestingly, the preference for sharks' teeth appears to be greater at Fort Center even though this site is located some distance from the coast and the cost of acquisition presumably would have been higher. Kozuch (1993:1, 25) notes a pattern of comparatively lower occurrences of sharks' teeth at coastal sites and suggests that it may be the result of trade relations with interior sites, i.e., the expected pattern of distribution of these materials would be away from the source location.

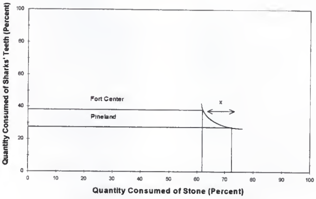


Figure 89. Relative change in the mixture of sharks' teeth and stone in the technological inventory as the cost of stone increases. The stronger arc of the indifference curve indicates that the two resources were not as substitutable for one another as were shell and stone. This is further indicated by the small difference in the resource mix (*X*) that occurs as a result of the increase in the cost of stone.

Summary. While the data are limited, they do illustrate a reduction in lithic demand during the post-Archaic period in the study area. The data also indicate the importance of shell and sharks' teeth as alternative raw materials for tool making in chert-poor areas, particularly during the post-Archaic period. The acquisition costs associated with siliceous stone when compared to marine shell appear to have been a significant factor in this shift in raw-material preference. Shell was apparently more substitutable for stone than sharks' teeth, as indicated by differences in the arcs of indifference curves, as well as the geographic distribution of sharks' teeth in archaeological assemblages.

Conclusion

The results of the analyses presented in this chapter indicate that Archaic and post-Archaic peoples both practiced strategies designed to minimize procurement costs associated with the acquisition of siliceous raw materials from distant source locations. However, as with the risk-reduction strategies discussed in Chapter 9, specific cost-reduction strategies varied temporally and, to a certain extent, spatially

Attempts to minimize transport costs are indicated by reductions in core size, tool size, and the amounts of cortex material in both Archaic and post-Archaic assemblages. Distance-decay patterns for core-size and amount of cortex material indicate that during the Archaic period unwanted waste materials were discarded fairly rapidly and within a short distance of source locations. These patterns are more variable for the post-Archaic period; fall-off patterns are not as abrupt and sites such as Fort Center and Pineland possess slightly larger cores and more cortex material than would be expected given their distances from chert sources. While Archaic and post-Archaic hafted bifaces are generally smaller in the study area than in contemporaneous assemblages from chert-rich areas, size variation is evident. This variation is believed to be due to the effects of differential procurement strategies and lithic economizing in combination with portability concerns. For example, while many Archaic hafted-biface types exhibit lower mean size indices than similar types in chert-rich areas, both large and small examples of each type are present; in other words, the range of sizes represented by these specimens is relatively large. When the size indices are plotted versus distance to resources, the resulting distance-decay pattern is consistent with the predicted pattern for mobile foragers transporting large, thin preforms and finished implements into a chert-poor area, and the subsequent planned staging of biface reduction and rejuvenation to ensure that raw materials were consistently available until a return trip to a chert source could be scheduled. In contrast, post-Archaic hafted-biface types exhibit a variety of distance-decay patterns that suggest several different procurement and transport practices, with down-the-line exchange and prestige exchange two of the more prominent.

Economizing strategies also were practiced during both cultural periods, although again there are differences Archaic hafted bifaces often exhibit pronounced lateral and/or distal resharpening while distal resharpening appears to have been more common on post-Archaic bifaces. Distal resharpening of Archaic hafted bifaces also appears to have contributed to the smaller mean sizes for some hafted-biface types, supporting the results of the size analysis. Efforts to conserve raw materials can also be seen among flake tools with both Archaic and post-Archaic assemblages in the study area possessing higher ratios of retouched to unretouched tools, higher numbers of utilized functional units on flake tools, and lower flake-to-flake-tool ratios than contemporaneous assemblages from chert-rich areas located farther north. Temporally, there is a slight tendency for post-Archaic assemblages in the study area to have higher ratios of retouched to unretouched tools; however, the differences are minor and not statistically significant. Similarly, there is very little temporal difference in terms of number of utilized functional edges on flake tools. Post-Archaic assemblages from the Peace River region do exhibit higher flake-to-flake-tool ratios than any of the other assemblages from the study area, and this is undoubtedly a result of having access to local Peace River cherts.

Attempts to reduce production costs are indicated during the post-Archaic period by a preference for small, amorphous cores and bipolar cores. In contrast to a prepared-core technology, these types of casual core-reduction strategies are less systematic and therefore less efficient in terms of raw-material use. However, they also are less costly in terms of time spent in learning and mastering special core-reduction techniques, and they minimize time spent in actual production.

Finally, the data suggest that attempts were made to reduce the demand for lithic raw materials. This is indicated archaeologically by a quantitative decline in the density of lithic artifacts through time. This decline is best represented at sites in the Kissimmee region where chronological controls enabled the separation of three temporally distinct assemblages equating to the preceramic Archaic, the early Belle Glade (i.e., Sears's Period I), and late Belle Glade (i.e., Periods II-IV) periods. This decline in lithic demand also is evident in the Peace River assemblages, albeit to a lesser degree. Again, the availability of local chert resources probably was a factor here.

A second indication of the reduced demand for chert is the substitution of marine shell and sharks' teeth in the technological inventories of post-Archaic groups. This is best observed at coastal sites where good preservation conditions exist, although archaeological evidence for the use of both of these materials is present in the Kissimmee region. Quantitative comparisons of the ratios of shell tools to lithic tools at Pineland and Yat Kitischee suggest that the degree to which shell was substituted for stone was partially due to the procurement costs associated with both resources. In other words, as the cost of acquiring stone increased (as measured by distance to chert source locations), the demand for shell increased. Although the shell tool assemblage from Fort Center is not as well quantified as those from Yat Kitischee and Pineland, it appears that the replacement of stone by shell was not as dramatic there, with the ratio of shell to stone tools approaching that of Yat Kitischee. I interpret this as being due to the relatively equal costs associated with both resources, i.e., they both were expensive to obtain. Thus, even though shell was a suitable substitute for stone, it does not appear to have been relied on to the extent that it was at Pineland where procurement costs for shell were minimal. Sharks' teeth are shown to have been less substitutable for stone than shell. This result reinforces other interpretations regarding the functional uses of this material, which appear to have been more restricted than either shell or stone. Interestingly, the ratio of sharks' teeth to stone tools is higher at Fort Center than at Pineland, in contrast to the pattern for shell tools. This may be due to the greater costs and risks associated with the acquisition of sharks' teeth coupled with the export of this commodity via trade to inhabitants of the south Florida interior.

There is an important contradiction to this general pattern of decreasing lithic demand through time. It appears that Archaic populations inhabiting the southwest coast were almost exclusively dependent on marine products for durable raw materials, more so at least than the post-Archaic inhabitants of Pineland. The apparent increase in demand for lithics on the southwest coast from Archaic to post-Archaic times is an interesting pattern that requires further research since it may be a reflection of an increase in exchange relations between the southwest coast and chert-rich areas farther north.

In Chapter 11 I turn to an examination of the strategies used to cope with opportunity costs. Specifically, I examine the extent to which curated and expedient technologies were utilized by Archaic and post-Archaic groups inhabiting the study area and interpret the differential uses of these technologies in light of expectations regarding time allocation.

CHAPTER 11
STRATEGIES FOR COPING WITH OPPORTUNITY COSTS

In this chapter I examine how Archaic and post-Archaic native peoples in south-central Florida coped with the problem of opportunity costs associated with the procurement and use of lithic raw materials. By necessity, the time and labor effort that were invested in the procurement, manufacture, use, and repair of tools prevented prehistoric hunter-gatherers from performing other activities that may have had higher fitness values. Time scheduling is expected to be most acute when there are a number of different activities that must be conducted within a set period of time (Hames 1992; Torrence 1989b). The optimal allocation of time is one in which an individual either maximizes the return on effort expended over a set period of time (resource maximization) or minimizes the amount of time spent conducting a specific activity (time minimization). If the first strategy was practiced prehistorically, then archaeological assemblages from the study area should exhibit high functional tool diversity and possess many specialized tools that were designed to increase work efficiency. Specialized tools require extra labor effort to produce and so these tools would likely have been curated in order to offset the high costs of production and maintenance. If time minimization was the operative strategy, then tool diversity should be low, multifunctional tools should be common, and assemblages should be dominated by expedient and casually produced tools and cores that required little labor effort to make.

Tool Diversity

Table 69 presents a breakdown of the various tool classes represented in the composite Archaic and post-Archaic assemblages from the Kissimmee and Peace River regions as well as from Fort Center,

Table 69. Summary of tool classes represented in Archaic and post-Archaic assemblages separated by region.

Tool Classes	KRArch		PRArch		KRPArch		PRPArch		8GL13		8LL33, 36,37		8PI1753	
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Hafted Bifaces[a]	16[b]	26.23	11	16.18	15	19.48	9	28.13	70	35.71	14	28.00	12	16.22
Other Bifaces	8	13.11	10	14.71	22	28.57	9	28.13	55	28.06	11	22.00	9	12.16
Unifaces	2	3.28	2	2.94	1	1.30	0	0.00	0	0.00	0	0.00	0	0.00
Stemmed Unifaces	0	0.00	0	0.00	0	0.00	0	0.00	1	0.51	0	0.00	0	0.00
Microliths	1	1.64	1	1.47	8	10.39	0	0.00	8	4.08	5	10.00	12	16.22
Utilized Flakes	24	39.34	30	44.12	24	31.17	8	25.00	43	21.94	11	22.00	22	29.73
Modified Flakes	10	16.39	12	17.65	7	9.09	6	18.75	12	6.12	6	12.00	10	13.51
Core Tools	0	0.00	2	2.94	0	0.00	0	0.00	0	0.00	0	0.00	2	2.70
Hammer-stones	0	0.00	0	0.00	0	0.00	0	0.00	7	3.57	3	6.00	7	9.46
Totals	61	100.00	68	100.00	77	100.00	32	100.00	196	100.00	50	100.00	74	100.00

[a] Includes stem fragments.

[b] Includes three hafted bifaces from a private collection.

Pineland, and Yat Kitischee. To examine assemblage diversity, measures of richness and evenness were calculated using the methods described in Chapter 6 and used in Chapter 9 to analyze raw-material diversity. Richness and evenness measures for the various assemblages are presented in Table 70 and a bivariate plot of these data is provided in Figure 90.

Both of the Archaic assemblages display comparatively low richness and evenness values indicating that they are the least diverse of the assemblages included in this analysis. This is indicated by their positions on the plot in Figure 90 where they are both situated to the left of the other assemblages. The composite assemblage from post-Archaic sites in the Peace River region possesses a very low richness value with only four of the nine tool classes represented, although artifacts are evenly distributed between these four classes.

Yat Kitischee (8PI1753) possesses the greatest tool diversity with high measures for both richness and evenness. The other post-Archaic sites are situated near the middle of the bivariate plot. Fort Center (8GL13), Pineland (8LL33, 36, 37), and the Kissimmee region assemblages all possess relatively similar richness and evenness measures indicating moderate diversity when compared with the other assemblages.

To evaluate the effect of sample size on the representation of different artifact classes, the data were compared to 200 simulated assemblages ranging in size from 1 to 200. The results are shown in Figure 91. With one exception, the numbers of tool classes in these assemblages are consistent with their sample sizes; in other words, the small differences in tool diversity indicated in Table 70 and Figure 90 are probably the result of differences in sample sizes between assemblages. The one exception is the composite post-Archaic assemblage from the Peace River region which contains fewer tool classes than would be expected for its sample size. An interpretation of low tool diversity would appear to be warranted for this assemblage.

Table 70. Richness (*R*) and evenness (*E*) values for Archaic and post-Archaic tool assemblages.

Assemblage	N	Tool Classes	*R*	Mean	SD	CV	*E*
Kissimmee Region Archaic	61	6	6.67	6.77	8.56	1.26	8.73
Peace River Region Archaic	68	7	7.78	7.56	9.74	1.29	8.71
Kissimmee Region Post-Archaic	70	6	6.67	7.78	9.61	1.12	8.88
Peace River Region Post-Archaic	32	4	4.44	3.56	4.30	1.21	8.79
8GL13	196	7	7.78	21.78	26.50	1.22	8.78
8LL33, 36, 37	50	6	6.67	5.56	5.36	.97	9.03
8PI1753	74	7	7.78	8.22	7.05	.86	9.14

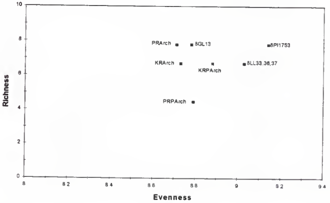


Figure 90. Bivariate plot of richness and evenness values for Archaic and post-Archaic tool assemblages.

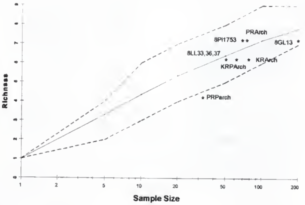


Figure 91. Relationship between number of tool classes (richness) and sample size for Archaic and post-Archaic assemblages. Sample size has been plotted on a logarithmic scale to produce a more interpretable plot.

Examination of Table 69 indicates that all of the assemblages are dominated by three tool classes: hafted bifaces, other bifaces, and utilized flakes. Modified flakes also are well represented. Essentially these tool classes can be collapsed into two: bifaces and flake tools. Unifaces are present in only three assemblages, two of which are Archaic, and stemmed unifaces occur in only one (Fort Center). Microliths are predominantly a post-Archaic phenomenon with 21 of the 23 examples of this tool class recovered from post-Archaic sites. Hammerstones also are associated strongly with the post-Archaic period with all 17 examples coming from three sites: Fort Center, Pineland, and Yat Kitischee. On the other hand, although utilized flakes are present in substantial quantities in the post-Archaic assemblages, they are the majority tool class in both of the composite Archaic period assemblages, accounting for over 40 percent of all tools.

Summary. Based on this analysis, tool diversity appears to be low for both Archaic and post-Archaic assemblages with two general classes of tools -- bifaces and flake tools -- dominating all assemblages. Although some variation in tool diversity is evident between assemblages, it does not appear to be significant and can be accounted for by differences in sample sizes. The only assemblage that can be considered significantly different is the composite post-Archaic assemblage from two sites in the Peace River region: 8HR44 and 8HR48. This difference can be accounted for by the absence of the minor tool classes such as microliths, unifaces, core tools, and hammerstones. Bifaces, utilized flakes, and modified flakes are common at both sites, which is consistent with all other assemblages included in the analysis.

Temporal variation in assemblage composition is present with post-Archaic sites containing more microliths and hammerstones. Archaic period sites appear to contain a greater proportion of flake tools, particularly utilized flakes. Unifaces are also more common in the Archaic assemblages; however, this pattern may be a consequence of the small number of artifacts that were assigned to this class.

Functional Diversity

Tables 71 and 72 present data on the number of functional tasks that were conducted for various tool classes as indicated by an analysis of use wear. To arrive at a measure of functional specialization, the average number of functional tasks per tool have been calculated by class and by assemblage. Multifunctional tool assemblages should exhibit a higher mean number of functional tasks per tool than assemblages that are more specialized. Tool classes that were used to conduct a variety of tasks should be associated with a higher number of functional tasks, while specialized tool classes should be associated with one or a very few functional tasks. Only those tools that exhibited observable and identifiable use-related edge damage are included in this table. Artifacts were not included if function was indeterminant, nor were unutilized production rejects or unutilized cores included.

Table 71. Cross-tabulation of functional tasks by artifact classes for Archaic and post-Archaic assemblages.

Assemblage/ Artifact Class	Cut/ Saw	Scrape	Engrave	Drill	Hammer	Chop	Projectile[a]	Totals	Total Tools[b]	Tasks Per Tool	Number of Tasks
Kissimmee Region Archaic											
Bifaces	2	2	0	0	0	0	10	14	13	1.08	3
Unifaces	0	2	0	0	0	0	0	2	2	1.00	2
Microliths	0	0	0	1	0	0	0	1	1	1.00	1
Utilized Flakes	12	22	2	0	0	0	0	36	24	1.50	3
Modified Flakes	2	6	1	1	0	0	0	10	8	1.25	4
Utilized Cores	0	0	0	0	0	0	0	0	0	.00	0
Hammerstones	0	0	0	0	0	0	0	0	0	.00	0
Totals	16	32	3	2	0	0	10	63	48	1.31	5
Peace River Region Archaic											
Bifaces	2	1	3	0	0	0	8	14	11	1.27	4
Unifaces	0	2	0	0	0	0	0	2	2	1.00	1
Microliths	0	0	0	0	0	0	0	0	0	.00	0
Utilized Flakes	19	16	1	3	0	0	0	39	30	1.30	4

Table 71 (Continued)

Assemblage/ Artifact Class	Cut/ Saw	Scrape	Engrave	Drill	Hammer	Chop	Projec-tile[a]	Totals	Total Tools[b]	Tasks Per Tool	Number of Tasks
Modified Flakes	4	7	2	0	0	0	0	13	11	1.18	3
Utilized Cores	0	0	0	0	1	1	0	2	2	1.00	2
Hammerstones	0	0	0	0	0	0	0	0	0	.00	0
Totals	25	26	6	3	0	0	8	70	56	1.25	7
Kissimmee Region Post-Archaic											
Bifaces	2	5	3	5	0	0	11	26	23	1.13	5
Unifaces	0	1	0	0	0	0	0	1	1	1.00	1
Microliths	0	4	0	4	0	0	0	8	7	1.14	2
Utilized Flakes	16	16	5	0	0	0	0	37	24	1.54	3
Modified Flakes	2	4	0	3	0	0	0	9	7	1.29	3
Utilized Cores	0	0	0	0	0	0	0	0	0	.00	0
Hammerstones	0	0	0	0	0	0	0	0	0	.00	0
Totals	20	30	8	12	0	0	11	81	62	1.31	5

Table 71 (Continued).

Assemblage/ Artifact Class	Cut/ Saw	Scrape	Engrave	Drill	Hammer	Chop	Projec-tile[a]	Totals	Total Tools[b]	Tasks Per Tool	Number of Tasks
Peace River Region Post-Archaic											
Bifaces	1	0	1	3	0	0	11	16	13	1.23	4
Unifaces	0	0	0	0	0	0	0	0	0	.00	0
Microliths	0	0	0	0	0	0	0	0	0	.00	0
Utilized Flakes	5	2	1	1	0	0	0	9	8	1.13	4
Modified Flakes	0	2	1	3	0	0	0	6	5	1.20	3
Utilized Cores	0	0	0	0	0	0	0	0	0	.00	0
Hammerstones	0	0	0	0	0	0	0	0	0	.00	0
Totals	6	4	3	7	0	0	11	31	26	1.19	5
8GL13											
Bifaces	24	31	10	8	0	3	36	112	86	1.30	6
Unifaces	1	1	1	0	0	0	0	3	1	3.00	1
Microliths	0	0	3	5	0	0	0	8	7	1.14	3

Table 71 (Continued).

Assemblage/ Artifact Class	Cut/ Saw	Scrape	Engrave	Drill	Hammer	Chop	Projec-tile[a]	Totals	Total Tools[b]	Tasks Per Tool	Number of Tasks
Utilized Flakes	16	35	6	0	0	0	0	57	43	1.33	3
Modified Flakes	0	9	2	1	0	1	0	13	12	1.08	4
Utilized Cores	0	0	0	0	0	0	0	0	0	.00	0
Hammerstones	0	0	0	0	0	0	7	7	7	1.00	1
Totals	41	76	22	14	7	4	36	200	156	1.28	7
8LL33, 36, 37											
Bifaces	6	11	2	7	0	0	11	37	20	1.85	5
Unifaces	0	0	0	0	0	0	0	0	0	.00	0
Microliths	0	3	2	4	0	0	0	9	5	1.80	3
Utilized Flakes	4	9	4	1	0	0	0	18	11	1.64	4
Modified Flakes	0	3	3	1	0	0	0	7	6	1.17	3
Utilized Cores	0	0	0	0	0	0	0	0	0	.00	0
Hammerstones	0	0	0	0	4	0	0	0	0	.00	1

Table 71 (Continued).

Assemblage/ Artifact Class	Cut/ Saw	Scrape	Engrave	Drill	Hammer	Chop	Projec- tile[a]	Totals	Total Tools[b]	Tasks Per Tool	Number of Tasks
Totals	10	26	11	13	4	0	11	75	46	1.63	6
8PI1753											
Bifaces	5	1	0	3	0	0	4	13	13	1.00	4
Unifaces	0	0	0	0	0	0	0	0	0	.00	0
Microliths	0	1	6	7	0	0	0	14	11	1.27	3
Utilized Flakes	12	11	1	1	0	0	0	25	22	1.14	4
Modified Flakes	4	7	0	1	0	0	0	12	9	1.33	3
Utilized Cores	0	0	0	0	1	1	0	2	2	1.00	2
Hammerstones	0	0	0	0	7	0	0	7	7	1.00	1
Totals	21	20	7	12	7	0	4	73	63	1.16	6

[a] Includes stems and distal fragments that exhibit evidence of impact damage resulting from use as projectiles.

[b] Includes only those tools that display observable use wear or other use-related damage.

Table 72. Summary data on functional variability between Archaic and post-Archaic tool assemblages.

Assemblages	Functional Tasks Per Tool	Number of Functional Tasks
Kissimmee Region Archaic	1.31	5
Peace River Region Archaic	1.25	5
Kissimmee Region Post-Archaic	1.31	5
Peace River Region Post-Archaic	1.19	5
Fort Center (8GL13)	1.28	7
Pineland (8LL33, 36, 37)	1.63	6
Yat Kitischee (8PI1753)	1.16	6

Although the differences in the mean number of functional tasks between assemblages are not great, the data do reveal some interesting temporal and geographic trends. For instance, while both of the regional Archaic period assemblages possess similar mean values, there is a relatively high degree of variability between post-Archaic assemblages. The two lowest mean values are associated with the composite post-Archaic assemblage from the Peace River region and Yat Kitischee (8PI1753). All of the sites included in these two assemblages are located near locally available chert resources. On the other hand, the two highest mean values are exhibited by the Pineland assemblage and the composite post-Archaic assemblage from the Kissimmee region. The sites that make up these assemblages are all located at some distance from the nearest chert source.

A second pattern that is revealed by these data is the consistently high number of functional tasks that are associated with flake tools. In nearly every assemblage utilized and modified flakes possess the highest or second highest average number of functional tasks per tool. Bifaces also tend to have high mean values, although this pattern is not as consistent between assemblages. These data suggest that flake tools, especially utilized flakes, were most likely to have been used for multiple tasks followed by modified flakes and bifaces. The use of microliths, unifaces, and hammerstones appears to have been restricted to a few specialized tasks.

As a class, bifaces tend to have more functional tasks associated with them than other tool classes. With one exception, the Archaic assemblage from the Kissimmee region, the number of functional tasks associated with bifaces ranges from 4 to 6. Interestingly, the assemblages that possess the highest numbers of functional tasks associated with this artifact class are Fort Center (6), Pineland (5), and the Kissimmee region post-Archaic assemblage (5).

Summary. These data indicate that the assemblages in the study collection are neither strongly specialized nor multifunctional, but instead include a mix of tools that were used for both specialized and general tasks. Flake tools, and to a certain extent bifaces, appear to have been the tools that were most often used to conduct several different tasks since individual specimens display a moderate amount of multifunctional use. More common, however, was the use of certain tool classes, rather than individual implements, to conduct a wide range of tasks; for example, the biface tool class is associated with the widest range of functional tasks in nearly all assemblages.

Multifunctional tool use is most strongly represented at both the assemblage and class levels by the post-Archaic assemblages, particularly those associated with sites that are located at some distance from a chert source. This, in combination with the observation that the composite Archaic assemblages do not differ greatly from one another, suggests that the inability to travel easily to chert source locations and stock up on needed raw materials may have been a factor in the use of stone tools for more than one task. In effect, multifunctional tool use at these sites represents a form of raw-material conservation.

Post-Archaic assemblages also have the greatest representation of tool classes that could be considered specialized; in other words, microliths and hammerstones. The latter are restricted to a single type of specialized task primarily by their form. As a class, microliths appear to have been used primarily to engrave and drill hard materials such as shell, bone, and wood, activities for which their size, form, and edge characteristics are well suited. Unifaces also appear to represent a functionally specialized tool class since all four examples display evidence of use as scrapers. The single stemmed uniface from Fort Center represents a different type of tool, perhaps more analogous to hafted bifaces. It was used in three different tasks and was obviously a multifunctional implement.

Organizational Structure: Tool Assemblages

In this section I examine the extent to which curated and expedient tools were used by Archaic and post-Archaic people in the study area. Table 73 provides data on the numbers of curated and expedient tools in each of the Archaic and post-Archaic assemblages used in this study. Similar data are presented for a selected sample of sites located in chert-rich areas in Hillsborough and Pinellas counties. For the purpose of this analysis, "curated" tools include bifaces and shaped unifaces while "expedient" tools include all flake tools, microliths, and utilized cores. The curated category is dominated by bifaces with only a few shaped unifaces present in any of the assemblages (see Table 69 and Appendices A and B).

It could be argued that modified flakes and microliths are not really expedient tools because both have experienced some degree of retouch and resharpening. In most cases, however, the retouch on modified flakes is minimal and consists of relatively minor edge rejuvenation. Moreover, the available evidence indicates that a relatively low-cost approach was taken in regard to the manufacture of flake tools and microliths. This approach included the production of flake "blanks" through bipolar- and/or amorphous-core reduction and minimal edge retouch that appears to have been restricted to edge rejuvenation during use. The time and labor investment associated with this type of technology is significantly less than the production costs associated with biface production. Evidence of hafting also was considered as a criterion for identifying curated tools; however, the physical evidence for hafting on flake tools is not always obvious. For this reason, hafting alone was not considered diagnostic

Table 73. Comparison of curated (C) and expedient (E) tools for Archaic and post-Archaic assemblages.

Assemblage	Curated Tools[a]	Expedient Tools[b]	C:E Ratio	References
Archaic Assemblages				
8HG18	0	3	.00	This study
8HG20	3	5	.60	This study
8HG27	0	0	.00	This study
8HG34	1	0	.00[c]	This study
8HG35	3[d]	4	.75	This study
8HG51	8	17	.47	This study
8HG678	7	5	1.40	This study
8HG767	4	3	1.33	This study
8HI473	41	276	.15	Chance 1982:Tables IV, VI, VIII; Chance and Misner 1984:Table 29
8HI476A	158	344	.46	Chance 1983a:Tables 11 and 13
8HI557	52	99	.53	Austin and Ste. Claire 1982:82
8HI559	3	8	.38	Austin and Ste. Claire 1982:58
8HR68	6	14	.43	This study
8HR71	4	11	.36	This study
8HR92	13	20	.65	This study
Wells	4	10	.40	This study
Post-Archaic Assemblages				
8GL13	125	64[e]	1.95	This study
8HG18	4	7	.57	This study
8HG20	6	9	.67	This study
8HG27	5	11	.46	This study
8HG34	0	1	.00	This study
8HG665	4	2	2.00	This study
8HG675	4	0	.00[c]	This study

Table 73 (Continued)

Assemblage	Curated Tools[a]	Expedient Tools[b]	C:E Ratio	References
8HG678	12	8	1.50	This study
8HI471	25	100	.25	Austin 1982:113
8HI556	48	141	.34	Austin and Ste. Claire 1982:146, Tables 21-22
8HR44	5	5	1.00	This study
8HR48	13	9	1.44	This study
8LL33, 36, 37	25	22	1.14	Austin 1995a; This study
8PI1753	21	53	.40	This study
8PO1685	3	1	3.00	This study

[a] Consists of bifaces and shaped unifaces

[b] Consists of utilized flakes, modified flakes, microliths, and utilized cores.

[c] Value of .00 is used since division by zero is not possible.

[d] Includes 3 hafted bifaces in private collection.

[e] Includes one chert cobble that has been bifacially worked along one edge.

enough to be used as a criterion for curation. Finally, by limiting the curated category to bifaces and unifaces it was possible to include published data from lithic assemblages in chert-rich areas for comparison.

As shown in Table 73, there are consistently higher ratios of curated to expedient tools among post-Archaic assemblages than there are among Archaic assemblages. Furthermore, there appears to be a greater dependence on curated tools in both the Archaic and post-Archaic assemblages from the chert-poor study area in comparison to assemblages from chert-rich areas located farther north. These comparisons are highlighted in Table 74 which compares composite Archaic and post-Archaic assemblages by region. A series of pair-wise chi-square tests indicates no significant differences between the composite Archaic assemblage from the Peace River region and the Archaic assemblage

Table 74. Comparison of curated (C) to expedient (E) tool ratios for Archaic and post-Archaic assemblages by geographic region.

Regions/ Assemblages	Curated Tools[a]	Expedient Tools[b]	C:E Ratio
Archaic Assemblages			
Kissimmee Region	26	39	.67
Peace River Region	23	43	.54
Hillsborough River Region	258	737	.35
Post-Archaic Assemblages			
Kissimmee Region	35	38	.92
Peace River Region	18	14	1.29
8GL13	125	64[c]	1.95
8LL33, 36, 37	25	22	1.14
Hillsborough/Pinellas counties	93	295	.32

[a] Consists of bifaces and shaped unifaces.
[a] Consists of utilized flakes, modified flakes, and microliths.
[c] Includes one bifacially worked chert cobble.

from the Hillsborough River region; however, the Kissimmee region Archaic assemblage is statistically different (Table 75). Significant differences also are apparent between both the Peace River and Kissimmee region post-Archaic assemblages and the contemporaneous assemblage from sites in Hillsborough and Pinellas counties. Finally, significant differences exist within the region between Archaic and post-Archaic assemblages, with the latter possessing consistently higher C:E ratios.

Summary. These data suggest that while dependence on a curated technology was greater in chert-poor areas than in chert-rich areas during both the Archaic and post-Archaic periods, there was a trend towards increased dependence on curated tools during the post-Archaic period within the study area. These results may be biased, however, since the data presented in Chapter 9 indicate that indirect procurement of lithic raw materials also increased during the post-Archaic. Furthermore, the forms in

Table 75. Results of pair-wise chi-square tests of independence comparing the frequencies of curated and expedient tools between regional Archaic and post-Archaic assemblages. Bold entries indicate significant differences ($p \leq .05$).

Assemblages	KR Arch	PR Arch	H Arch	KR PArch	PR PArch	8GL13	8LL33, 36, 37	H/P PArch
Kissimmee Region Archaic	---	X^2obs = .564 *df* = 1 *p* = 453	**X^2obs = 6.159 *df* = 1 *p* = .013**	X^2obs = .609 *df* = 1 *p* = .435	X^2obs = 1.915 *df* = 1 *p* = .166	**X^2obs = 13.707 *df* = 1 *p* = .0002**	X^2obs = 1.538 *df* = 1 *p* = .215	**X^2obs = 8.203 *df* = 1 *p* = .004**
Peace River Region Archaic		---	X^2obs = 2.529 *df* = 1 *p* = .112	X^2obs = 2.445 *df* = 1 *p* = .118	**X^2obs = 4.057 *df* = 1 *p* = .044**	**X^2obs = 19.665 *df* = 1 *p* = <.0001**	X^2obs = 3.780 *df* = 1 *p* = .052	X^2obs = 3.418 *df* = 1 *p* = .065
Hillsborough County Archaic			---	**X^2obs = 16.558 *df* = 1 *p* = <.0001**	**X^2obs = 14.503 *df* = 1 *p* = <.0001**	**X^2obs = 117.335 *df* = 1 *p* = <.0001**	**X^2obs = 16.861 *df* = 1 *p* = <.0001**	X^2obs = .567 *df* = 1 *p* = .452
Kissimmee Region Post-Archaic				---	X^2obs = .614 *df* = 1 *p* = .433	**X^2obs = 7.331 *df* = 1 *p* = .007**	X^2obs = .315 *df* = 1 *p* = .575	**X^2obs = 17.367 *df* = 1 *p* = < .0001**
Peace River Region Post-Archaic					---	X^2obs = 1.172 *df* = 1 *p* = .279	X^2obs = .072 *df* = 1 *p* = .789	**X^2obs = 15.667 *df* = 1 *p* = < .0001**
8GL13						---	X^2obs = 2.724 *df* = 1 *p* = .099	**X^2obs = 96.138 *df* = 1 *p* = < .0001**

Table 75 (Continued).

Assemblages	KR Arch	PR Arch	H Arch	KR PArch	PR PArch	8GL13	8LL33, 36, 37	H/P PArch
8LL33,36,37							---	**X^2obs = 17.894** **$df = 1$** **$p = < .0001$**
Hillsborough/ Pinellas Counties Post-Archaic								---

which these raw materials were exchanged appear to have been complete or nearly complete bifaces. Thus, curated tools, which are dominated by bifaces, may be common at post-Archaic sites because they were obtained via exchange. Amorphous cores also are common (see Table 65) and this implies that on-site reduction of these cores to produce flake tools and microliths was a major technological activity. In the next section I present the results of a debitage analysis which provide additional support for this interpretation.

Organizational Structure: Debitage Assemblages

This section examines the different ways in which lithic raw materials were used by Archaic and post-Archaic peoples once the materials arrived at the sites. This is accomplished through a technological analysis of debitage using the methods described in Chapter 8.

Sullivan-Rozen Analysis

Table 76 presents raw frequencies and percentages of the Sullivan-Rozen debitage categories by site for Archaic and post-Archaic assemblages, respectively. The debitage assemblages include utilized and modified flakes since most of these were produced by the same reduction activities that resulted in unutilized debitage. These data were subjected to a discriminant analysis that compared them to the experimentally produced waste-flake assemblages discussed in Chapter 8. The individual site assemblages are discussed first without regard for differences between raw-material types. These are then broken down by raw-material type and reclassified to illustrate how different raw materials were used in different ways at many sites.

Archaic assemblages. Of the 10 Archaic assemblages that were subjected to the discriminant-function classification procedure, five were assigned to the core-reduction group and five were assigned to the patterned-tool group (Table 77). Figure 92 shows that four of the assemblages (8HG51, 8HR68, 8HR71, and 8HR92) are positioned well to the right of the group centroid for flake

Table 76. Results of Sullivan-Rozen debitage analysis for Archaic and post-Archaic assemblages.

Site	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct	N	Pct.	N	Pct.	
Archaic Assemblages									
8HG18	9	22.50	13	32.50	15	37.50	3	7.50	40
8HG20	10	38.46	6	23.08	9	34.62	1	3.85	26
8HG34	5	18.52	6	22.22	16	59.26	0	.00	27
8HG35	15	26.79	17	30.36	23	41.07	1	1.79	56
8HG51	141	24.27	108	18.59	293	50.43	39	6.71	581
8HG678	17	34.69	12	24.49	13	26.53	7	14.29	49
8HG767	14	32.56	7	16.28	22	51.16	0	.00	43
8HR68	79	29.37	77	28.62	109	40.52	4	1.49	269
8HR71	101	39.15	44	17.05	97	37.60	16	6.20	258
8HR92	127	25.71	115	23.28	228	46.15	24	4.86	494
Post-Archaic Assemblages									
8GL13	196	29.65	99	14.98	183	27.68	183	27.68	661
8HG18	19	21.84	35	40.23	30	34.48	3	3.45	87
8HG20	44	39.29	20	17.86	46	41.07	2	1.79	112
8HG27	22	30.99	21	29.58	27	38.03	1	1.41	71
8HG678	18	22.79	13	16.46	29	36.71	19	24.05	79

Table 76 (Continued).

Site	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct	N	Pct.	N	Pct.	
8HR44	41	23.70	24	13.87	99	57.23	9	5.20	173
8HR48	90	48.91	25	13.59	55	29.89	14	7.61	184
8LL33,36,37	33	35.87	12	13.04	29	31.52	18	19.57	92
8PI1753	150	41.67	55	15.28	122	33.89	33	9.17	360

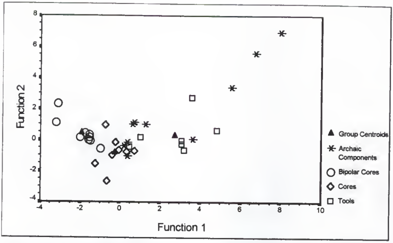


Figure 92. Bivariate plot of discriminant-function scores comparing Archaic debitage assemblages with experimentally produced debitage assemblages.

Table 77. Multivariate classification of Archaic debitage assemblages.

Site	Discriminant Scores		Group Assignment	Probability of Correct Assignment
	Function 1	Function 2		
8HG18	.7456	1.1508	Core	.5484
8HG20	.3978	-.1517	Core	.8383
8HG34	.2342	-.3449	Core	.8907
8HG35	1.2934	1.0405	Tool	.8663
8HG51	5.5804	3.4140	Tool	1.0000
8HG678	.5873	1.0793	Core	6704
8HG767	.4690	-.8719	Core	8366
8HR68	6.7696	5.6253	Tool	1.0000
8HR71	3.6602	.0748	Tool	1.0000
8HR92	8.0168	6.9654	Tool	1.0000

assemblages resulting from patterned-tool reduction. Examination of Table 76 indicates that these four sites are all fairly similar in terms of the proportional representation of the four flake categories. All have moderately high percentages of proximal flake fragments and low percentages of nonorientable fragments. Similarly, when the Ogive curves for these four assemblages are compared to those of the experimentally produced flake assemblages (Figures 93-96), all four parallel closely the patterned-tool reduction curve.

The fifth patterned-tool assemblage, 8HG35, is positioned to the left of the group centroid for patterned tools and is very close to the experimental core-reduction group (Figure 92). The Ogive curve for this assemblage, however, indicates a close similarity to the experimental patterned-tool assemblage (Figure 97), and the proportional distribution of flakes between the four Sullivan-Rozen categories is very similar to those from the other four Archaic patterned-tool assemblages (Table 76).

Of the five assemblages that were classified as resulting from core-reduction, one (8HG678) likely represents a mixed assemblage. It is one of three Archaic assemblages that are clustered to the upper right of the group centroid for the experimental core-reduction group in Figure 92. The probability of group membership for this assemblage was fairly low (.6403) and, while not shown in Table 77, the second highest probability for group membership was the patterned-tool group (p = .3597). The Ogive curve (Figure 98) also indicates a mixture of tool and core-reduction debitage. The left side of the curve parallels closely the patterned-tool curve, with the proportional representation of complete and proximal flakes very similar to the other Archaic assemblages that were classified as patterned-tool assemblages (Table 76). However, the right side of the curve is more similar to the experimental small-core reduction assemblage. This is a result of slightly lower numbers of medial-distal fragments and a comparatively high percentage of nonorientable fragments (12.77 percent).

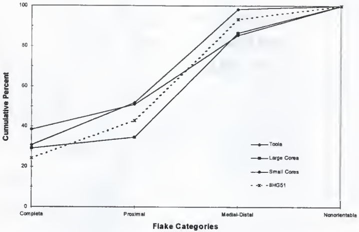


Figure 93. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HG51 with experimentally produced debitage assemblages.

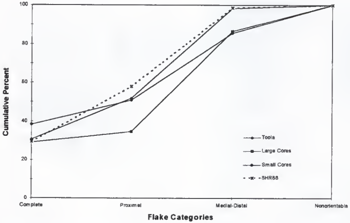


Figure 94 Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HR68 with experimentally produced debitage assemblages.

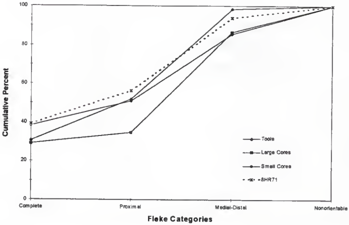


Figure 95. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HR71 with experimentally produced debitage assemblages.

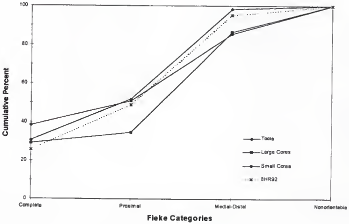


Figure 96. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HR92 with experimentally produced debitage assemblages.

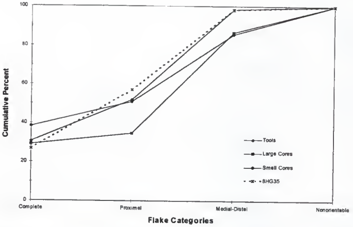


Figure 97. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HG35 with experimentally produced debitage assemblages.

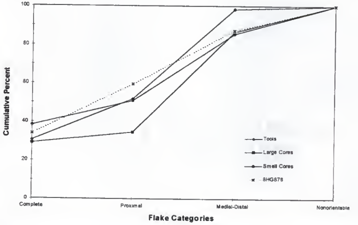


Figure 98. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the Archaic assemblage from 8HG678 with experimentally produced debitage assemblages.

Three of the assemblages classified as resulting from core reduction come from preceramic submidden components along the Kissimmee River (8HG18, 8HG20, and 8HG34). Examination of the Ogive curves for these three assemblages indicates that only the assemblage from 8HG34 could be considered a possible candidate for a mixed assemblage (Figures 99-101). The left side of this curve (Figure 101) is very similar to the experimental large-core reduction assemblage and the right side is similar to the patterned- tool reduction curve. The other two archaeological assemblages seem to be more similar overall to the experimental patterned-tool assemblage. However, all of the archaeological assemblages are very small and it was suspected that this may have been a factor in their multivariate assignment to the core-reduction group. Since these three sites are located in close geographic proximity to one another, the debitage data were combined into a single composite assemblage. In addition, three flakes (1 complete, 2 medial-distal) from the preceramic component at 8HG27, which also is located nearby, were added to this assemblage. The composite assemblage was reclassified by discriminant analysis as belonging to the patterned-tool group (Table 78) and the Ogive curve for the assemblage shows a clear parallel with the experimentally produced patterned-tool assemblage (Figure 102).

The final Archaic assemblage to be considered is from 8HG767. This was classified by discriminant analysis as resulting from core-reduction (Table 77). It is not clear why this assemblage was so classified. Examination of the Ogive curve for the 8HG767 assemblage indicates a very close resemblance to the experimental tool-reduction assemblage (Figure 103). The archaeological assemblage contains no nonorientable fragments (Table 76); however, the proximal flake category is the lowest of all the Archaic assemblages (16.28 percent) and this may have been a factor in its assignment. I believe that this assemblage was misclassified by the discriminant analysis, a conclusion that I believe is supported by the flake-size analysis that is described below, as well as by the absence of cores at the site (Appendix A).

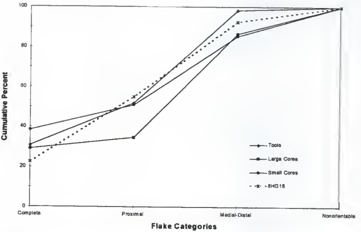


Figure 99. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the Archaic assemblage from 8HG18 with experimentally produced debitage assemblages.

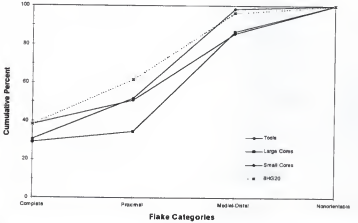


Figure 100. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the Archaic assemblage from 8HG20 with experimentally produced debitage assemblages.

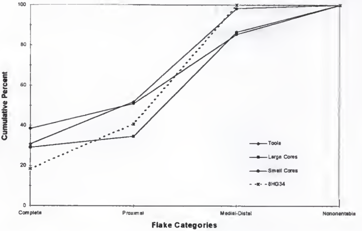


Figure 101. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HG34 with experimentally produced debitage assemblages.

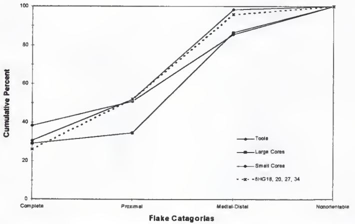


Figure 102. Comparison of the cumulative proportions of the combined Sullivan-Rozen debitage categories in the Archaic assemblages from 8HG18, 8HG20, 8HG27, and 8HG34 with experimentally produced debitage assemblages.

Table 78. Multivariate classification of composite debitage assemblages from Archaic and post-Archaic components at 8HG18, 8HG20, 8HG27, and 8HG34.

Cultural-Temporal Component	Discriminant Scores		Group Assignment	Probability of Correct Assignment
	Function 1	Function 2		
Archaic	1.7420	1.4905	Tool	.9853
Post-Archaic	7.0928	5.9673	Tool	1.0000

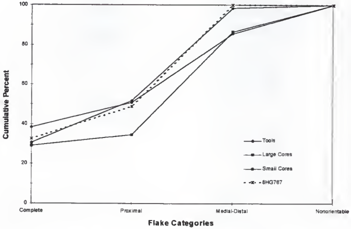


Figure 103. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HG767 with experimentally produced debitage assemblages.

Only four Archaic assemblages were large enough to enable meaningful comparisons between raw material types: 8HG51, 8HR68, 8HR71, and 8HR92. The remaining assemblages were small and/or tended to be dominated by cherts from a single quarry cluster, the Hillsborough River. Although other quarry clusters are represented in these assemblages, the number of flakes that could be associated with each tended to be quite small, often less than 25. Attempts to use cumulative proportions and discriminant analysis with samples smaller than this provided inconsistent results. In some cases, chert types (see Chapter 7) from the Hillsborough River Quarry Cluster were well enough represented to enable separate analysis; otherwise all Hillsborough River Quarry Cluster cherts were combined into a single category. Table 79 provides the Sullivan-Rozen data for selected raw materials from the four sites mentioned above. Table 80 provides the discriminant scores and classifications.

Three of the four raw materials at 8HG51 have been classified by the discriminant analysis as resulting from patterned-tool production while one, Withlacoochee Quarry Cluster chert, was classified as resulting from core-reduction (Table 80). Examination of the Ogive curves for Hillsborough River cherts, Withlacoochee cherts, and silicified coral all indicate very close similarities to the experimental patterned-tool assemblage while Peace River cherts seem to indicate a mix of tool and core-reduction debris (Figure 104). The fact that the majority of the Peace River debitage was found in two localized concentrations in association with discarded bifaces of the same material indicates that most of this debitage was the product of biface reduction. Examination of the data in Table 79 indicates that Peace River cherts have fewer complete flakes and more nonorientable fragments than the other three raw materials, which is probably due to the brittle nature of this opal-rich chert. Discriminant classification of the Withlacoochee cherts as resulting from core-reduction is puzzling since the proportional representation of the various Sullivan-Rozen flake categories does not appear to be significantly different from either the Hillsborough River cherts or silicified coral (Table 79). It is possible that this debitage represents an earlier stage of biface reduction than the other chert types and so was positioned closer to the group centroid for core-reduction (see Chapter 8).

Turning to the Archaic assemblages from the Peace River valley, the composite Hillsborough River Quarry Cluster cherts were consistently classified by the discriminant analysis as resulting from patterned-tool reduction (Table 80). Except where noted in Table 79, these assemblages consisted primarily of "generic" Hillsborough River cherts with only small amounts of Cow House Creek, Bay Bottom, or Type 4 cherts present (see Appendix A). The Ogive curves for the Hillsborough River

Table 79. Results of Sullivan-Rozen debitage analysis for selected Archaic assemblages controlled for raw-material type

Site/ Raw-Material Type	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
8HG51									
Hillsborough River QC	20	31.75	16	25.40	27	42.86	0	0.00	63
Peace River	89	22.42	63	15.87	209	52.64	36	9.07	397
Withlacoochee QC	9	30.00	7	23.33	14	46.67	0	0.00	30
Silicified Coral	18	30.51	17	28.81	23	38.98	1	1.69	59
8HR68									
Hillsborough River QC[a]	53	30.99	41	23.98	75	43.86	2	1.17	171
Cow House Creek	5	18.52	11	40.74	11	40.74	0	0.00	27
8HR71									
Hillsborough River QC	58	41.13	18	12.77	53	37.59	12	8.51	141
Withlacoochee QC	26	44.07	17	28.81	16	27.12	0	0.00	59
Silicified Coral	8	32.00	5	20.00	12	48.00	0	0.00	25
8HR92									
Hillsborough River QC[b]	55	25.70	44	20.56	105	49.07	10	4.67	214
Cow House Creek	11	25.00	11	25.00	19	43.18	3	6.82	44

Table 79 (Continued).

Site/ Raw-Material Type	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Bay Bottom	5	19.23	7	26.92	11	42.31	3	11.54	26
Withlacoochee QC	18	30.00	14	23.33	26	43.33	2	3.33	60
Silicified Coral	20	28.99	18	26.09	30	43.48	1	1.45	69

[a] All Hillsborough River Quarry Cluster cherts except Cow House Creek.

[b] All Hillsborough River Quarry Cluster cherts except Cow House Creek and Bay Bottom.

Table 80. Multivariate classification of raw materials from selected Archaic debitage assemblages.

Site/ Raw Material Type	Discriminant Scores		Group Assignment	Probability of Correct Assignment
	Function 1	Function 2		
8HG51				
Hillsborough River QC	1.3530	.3173	Tool	.8724
Peace River QC	1.7291	1.0149	Tool	9818
Withlacoochee QC	.4607	-.2522	Core	.8184
Silicified Coral	1.3731	.8960	Tool	.8986
8HR68				
Hillsborough River QC[a]	3.5549	1.4232	Tool	1.0000
Cow House Creek	.7578	.8447	Core	.5659
8HR71				
Hillsborough River QC	1.1976	-1.1344	Tool	.7157
Withlacoochee QC	1.7726	.7401	Tool	.9844
Silicified Coral	.2870	-.4904	Core	.8823
8HR92				
Hillsborough River QC[b]	2.7832	1.2964	Tool	1.0000
Cow House Creek	.5581	.4840	Core	.7324
Bay Bottom	.1667	.3896	Core	.7324
Withlacoochee QC	.9807	.2846	Tool	.5863
Silicified Coral	1.4064	.6587	Tool	.9059

[a] All Hillsborough River Quarry Cluster cherts except Cow House Creek.

[b] All Hillsborough River Quarry Cluster cherts except Cow House Creek and Bay Bottom.

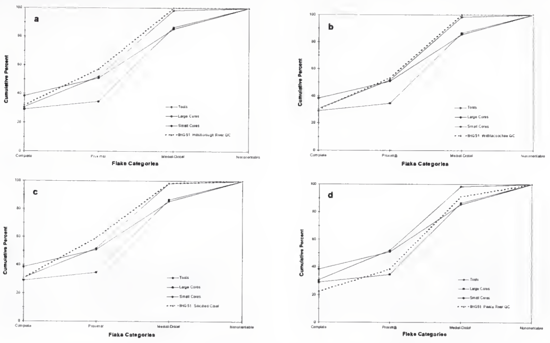


Figure104. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for selected raw materials from 8HG51 with experimentally produced debitage assemblages: a) Hillsborough River Quarry Cluster; b) Withlacoochee Quarry Cluster; c) silicified coral; d) Peace River Quarry Cluster.

materials suggest that some core reduction may have occurred as well (Figure 105). This is supported by the recovery of a small core from 8HR68 and two small cores from 8HR92, all made from "generic" Hillsborough River chert (Appendix A). The generally high probability of correct assignment for these cherts, and the fact that large proportions of the biface assemblages from all three sites are made from this raw material, indicates that patterned-tool reduction was the primary technology involving Hillsborough River cherts and that the reduction of small bifacial cores was a secondary, and relatively minor, component of the technology.

Cow House Creek cherts from the Hillsborough River Quarry Cluster were present in large enough amounts at both 8HR68 and 8HR92 to analyze separately from other Hillsborough River cherts. The debitage assemblages from both of these sites were classified by discriminant analysis as resulting from core reduction (Table 80), and the Ogive curves for this material seem to support this classification (Figure 106). The recovery of a small bifacial core made from Cow House Creek chert from 8HR68 provides additional supporting evidence (Appendix A). Bay Bottom chert from 8HR92 also was classified as resulting from core reduction (Table 80) although the Ogive curve suggests the possibility of a mixed assemblage (Figure 107). The small size of this sample (N=27) also may have affected the results.

Withlacoochee Quarry Cluster cherts were classified as coming from patterned-tool reduction for both 8HR71 and 8HR92 (Table 80). The Ogive curve from 8HR71 is difficult to interpret (Figure 108a). There is a high proportion of complete flakes in comparison to the experimental assemblages, and only moderate amounts of proximal and medial-distal fragments (Table 79). This results in an Ogive curve that is unlike any of the experimental assemblages. However, the absence of nonorientable fragments and the moderate amounts of proximal and medial-distal fragments makes it likely that this assemblage is primarily the result of tool production rather than core-reduction. The curve for Withlacoochee cherts from 8HR92 is virtually identical to the experimental tool-reduction curve (Figure 108b).

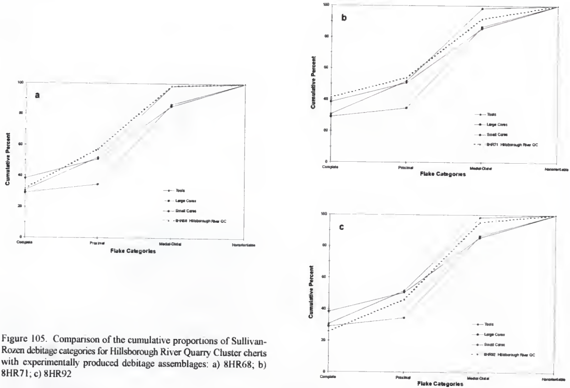


Figure 105. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Hillsborough River Quarry Cluster cherts with experimentally produced debitage assemblages: a) 8HR68; b) 8HR71; c) 8HR92

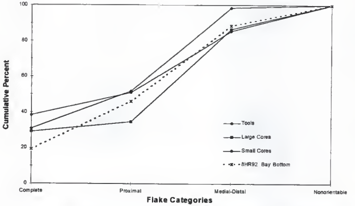
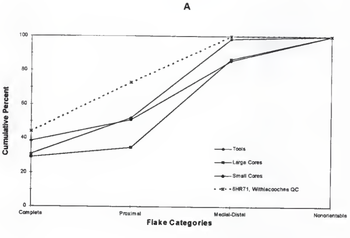


Figure 107. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Bay Bottom chert from 8HR92.

The final raw material to be considered is silicified coral. The discriminant analysis classified this material as resulting from core-reduction at 8HR71 and patterned-tool reduction at 8HR92 (Table 80); however, the Ogive curves for this material strongly indicate patterned-tool reduction at both sites (Figure 109). Again, the discrepancy between the discriminant classification and the cumulative proportion curve for the 8HR71 assemblage appears to be the result of a small sample (N=25).

Post-Archaic assemblages. The discriminant analysis classified six of the post-Archaic assemblages as resulting from patterned-tool production and three from core reduction (Table 81). In Figure 110, the four assemblages that are positioned most closely to the group centroid for the experimental flake assemblages resulting from tool production are those from 8HG18, 8HG20, 8HG27, and 8HR48. Visual comparison of the cumulative percentages (Ogive curves) for these assemblages with those resulting from experimental core and tool reduction (Figures 111-114) tends to support the multivariate classification results. (Note that these and subsequent figures showing cumulative pro-



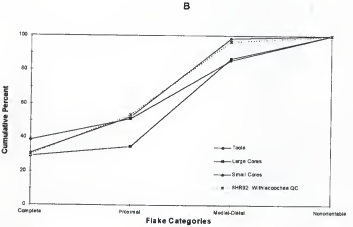


Figure 108. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Withlacoochee Quarry Cluster chert with experimentally produced debitage assemblages: a) 8HR71; b) 8HR92.

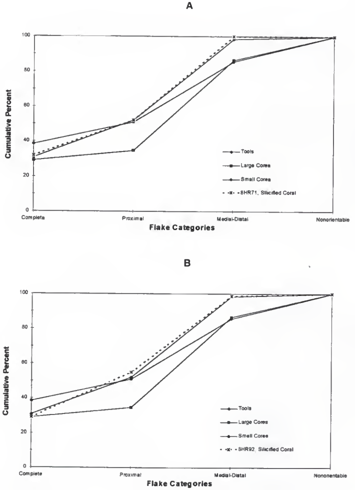


Figure 109. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for silicified coral with experimentally produced debitage assemblages: a) 8HR71; b) 8HR92.

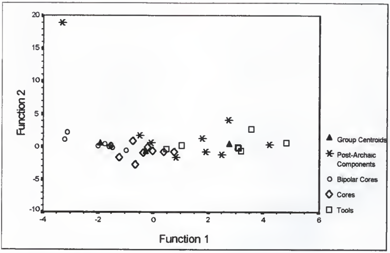


Figure 110. Bivariate plot of discriminant-function scores comparing post-Archaic debitage assemblages with experimentally produced debitage assemblages.

Table 81. Multivariate classification of post-Archaic debitage assemblages.

Site	Discriminant Scores		Group Assignment	Probability of Correct Assignment
	Function 1	Function 2		
8GL13	-3.3294	18.8045	Tool	1.0000
8HG18	2.7392	4.1509	Tool	1.0000
8HG20	1.8949	-.7713	Tool	.9893
8HG27	1.7737	1.2761	Tool	.9867
8HG678	-.4841	1.6921	Core	.9113
8HR44	.7999	-1.6586	Core	.6691
8HR48	2.4840	-1.2312	Tool	.9997
8LL33,36, 37	-.0968	.6770	Core	.9150
8PI1753	4.2241	.3676	Tool	1.0000

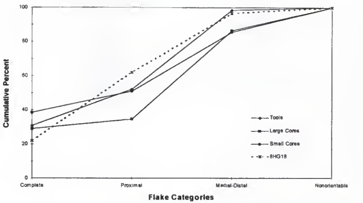


Figure 111. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the post-Archaic assemblage from 8HG18 with experimentally produced debitage assemblages.

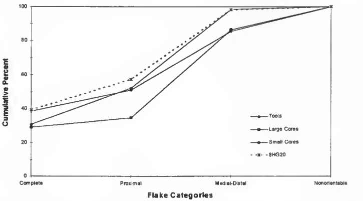


Figure 112. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the post-Archaic assemblage from 8HG20 with experimentally produced debitage assemblages.

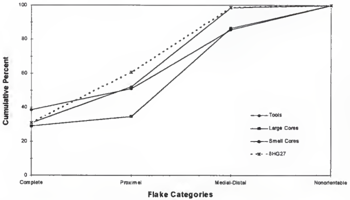


Figure 113. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the post-Archaic assemblage from 8HG27 with experimentally produced debitage assemblages.

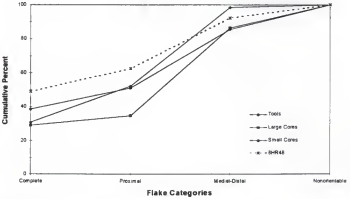


Figure 114. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8HR48 with experimentally produced debitage assemblages.

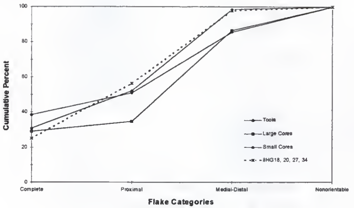


Figure 115. Comparison of the cumulative proportions of the combined Sullivan-Rozen debitage categories in the post-Archaic assemblages from 8HG18, 8HG20, 8HG27, and 8HG34 with experimentally produced debitage assemblages.

portions for post-Archaic assemblages have had Kuijt et al.'s [1995] experimental flake assemblage data from the reduction of bipolar cores added. See Chapter 8, Table 10 for the raw data.)

Although the post-Archaic debitage assemblages from the three Kissimmee River sites were substantially larger than their corresponding Archaic assemblages, I did combine the post-Archaic debitage data from 8HG18, 8HG20, and 8HG27, and included eight flakes (3 complete, 3 proximal, 2 medial-distal) from the post-Archaic component at 8HG34, in order to test the results of the individual assemblage assignments. The discriminant analysis (Table 78) and the cumulative distribution curve (Figure 115) both indicate that this composite post-Archaic assemblage is the result of patterned-tool reduction supporting the analyses of the individual assemblages.

Also assigned to the tool-reduction group were the flake assemblages from Fort Center (8GL13) and Yat Kitischee (8PI1753). Examination of Figure 110 indicates that Fort Center is situated in the extreme upper left corner of the plot. Visually, this assemblage appears more similar to the bipolar-core group, which is situated on the left side of the plot, than the patterned-tool group, which is situated to the far right. This interpretation is supported by the extremely high proportion of nonorientable fragments in this assemblage (27.7 percent; see Table 79). When the cumulative percentage distribution of the four flake categories from Fort Center is compared visually with those from the experimental flake assemblages, the resulting Ogive curve appears most similar to the large-core assemblage, although the effect on the curve of the large number of nonorientable fragments is clearly evident, further suggesting that the debitage from this site contains a significant bipolar-reduction component (Figure 116).

The flake assemblage from Yat Kitischee (8PI1753) is situated to the far right of the plot in Figure 110 and was classified as most similar to the experimental assemblages resulting from patterned-tool reduction. The Ogive curve for this assemblage indicates a distribution that is somewhat intermediate between patterned-tool reduction and small-core reduction (Figure 117). The fact that the assemblage contains more complete flakes and fewer medial-distal fragments than would be expected for an assemblage resulting from patterned-tool reduction results in a curve that crosses the experimental patterned-tool curve and approaches that of the experimental small-core assemblage. Because of this, and despite the multivariate classification of this assemblage as resulting from patterned-tool reduction, it appears that the flake assemblage from 8PI1753 represents a mixed assemblage resulting from at least two different types of reduction strategies. This interpretation is supported by the large numbers of cores and bifaces in the assemblage (Appendix B).

The three components that were assigned to the core-reduction group are Pineland (8LL33, 36, 37), Blueberry (8HG678), and 8HR44. The site that has the greatest probability of correct assignment is Pineland (p = 9150). Examination of the Ogive curve for this site's flake assemblage indicates a very close agreement between it and the curve resulting from the experimental reduction of small cores (Figure 118). The flake distribution for the Blueberry site also is quite similar to the experimental

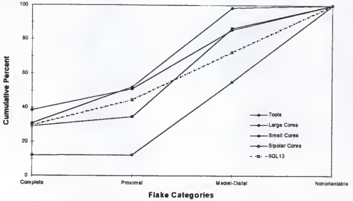


Figure 116. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8GL13 with experimentally produced debitage assemblages.

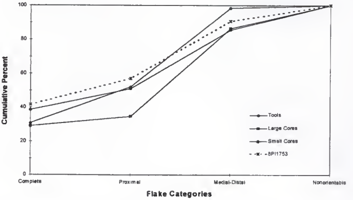


Figure 117. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8PI1753 with experimentally produced debitage assemblages

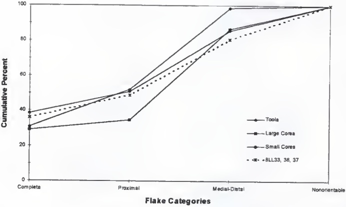


Figure 118. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories from 8LL33, 36, 37 with experimentally produced debitage assemblages.

small-core flake assemblage, although there are fewer complete flakes than would be expected (Figure 119). Trampling could have decreased the number of complete flakes in this assemblage; however, the low numbers of waste flakes, their overall small size (86.08 percent are less than 1.5 cm in maximum dimension), and their widely scattered distribution throughout the site's sandy soil matrix do not seem to offer the types of conditions conducive to high rates of trampling damage (cf. Pryor 1988).

When the Ogive curve for the flake assemblage from 8HR44 is examined, it appears that this assemblage represents a mixture of patterned-tool and core-reduction debitage (Figure 120). The left side of the curve is most similar to core reduction with relatively small numbers of proximal fragments; however, the number of medial-distal fragments is quite high and the right side of the curve is more similar to flake assemblages resulting from patterned-tool reduction. This assemblage is dominated by Peace River Quarry Cluster cherts (Appendix B) and the only core recovered from this site is manu-

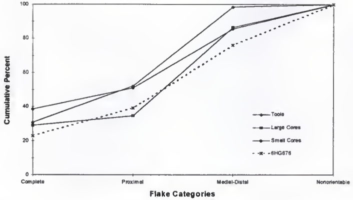


Figure 119. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the post-Archaic assemblage from 8HG678 with experimentally produced debitage assemblages.

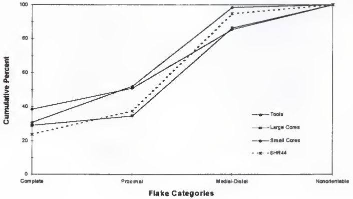


Figure 120. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories in the post-Archaic assemblage from 8R44 with experimentally produced debitage assemblages.

factured from this material. This supports an interpretation of a mixed assemblage, although patterned-tool reduction may have been dominant.

To obtain a more refined characterization of the reduction strategies that occurred at these sites, the flake assemblages were divided by raw-material type and a new series of analyses was conducted. As with the Archaic assemblages, some post-Archaic assemblages tended to be dominated by chert from a single quarry cluster. For example, cherts from the Hillsborough River Quarry Cluster are well represented in all of the Kissimmee River (8HG18, 8HG20, and 8HG27) sites and at Pineland (8LL33, 36, 37). On the other hand, 8HR44 is dominated by chert from the Peace River Quarry Cluster. Other chert types were not well enough represented at these sites to allow for meaningful comparisons. For this reason only four sites were included in the raw-material comparisons: 8GL13, 8HG678, 8HR48, and 8PI1753. The raw data for these sites are presented in Table 82 and the multivariate classification results are presented in Table 83.

The results of this new set of analyses provide additional insights into the use of various raw materials at these post-Archaic sites. For example, of the four raw-material categories in the Yat Kitischee assemblage that were well enough represented to be analyzed separately, two were classified as being most similar to the experimental core-reduction flake assemblages (Table 83). These include both of the Turtlecrawl Point chert types. Examination of the Ogive curves for these two assemblages indicates somewhat unusual distributions (Figures 121a and 121b). The Type 1 variety of Turtlecrawl Point chert consists of flakes resulting from the reduction of the dark-colored, homogeneous, chert "rods" that were used exclusively for the manufacture of microliths (Austin 1995b). The presence of debitage and cores that display the characteristic attributes of bipolar reduction (see Chapter 10) led me to expect that this assemblage would exhibit an Ogive curve similar to that resulting from experimental bipolar-core reduction. However, as Figure 121a shows, the flake assemblage from Yat Kitischee has a much higher proportion of complete flakes than any of the experimental assemblages (58.2 percent;

Table 82 Results of Sullivan-Rozen debitage analysis for selected post-Archaic assemblages controlled for raw-material type

Site/ Raw-Material Type	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
8GL13									
Cobbles	65	23.38	13	4.68	72	25.90	128	46.04	278
Hillsborough River QC	73	37.63	46	23.71	59	30.41	16	8.25	194
Silicified Coral	7	18.42	11	28.95	13	34.21	7	18.42	38
Peace River QC	16	51.61	5	16.13	7	22.58	3	9.68	31
Non-chert Stone[a]	4	16.67	1	4.17	6	25.00	13	54.17	24
8HG678									
Hillsborough River QC	9	27.27	7	21.21	7	21.21	10	30.30	33
Peace River QC	7	25.93	1	3.70	12	44.44	7	25.93	27
8HR48									
Hillsborough River QC	25	50.00	10	20.00	14	28.00	1	2.00	50
Peace River QC	38	50.00	6	7.89	26	34.21	6	7.89	76
8PI1753									
Turtlecrawl Point, Type 1[b]	39	58.21	3	4.48	17	25.37	8	11.94	67
Turtlecrawl Point, Type 2[c]	15	60.00	2	8.00	7	28.00	1	4.00	25
Hillsborough River, Type 4	22	31.88	18	26.09	25	36.23	4	5.80	69

Table 82 (Continued).

Site/ Raw-Material Type	Complete		Proximal		Medial-Distal		Nonorientable		Totals
	N	Pct.	N	Pct.	N	Pct.	N	Pct.	
Hillsborough River QC[d]	44	33.85	25	19.23	47	36.15	14	10.77	130

[a] Dolomite, quartz, and fossil bone.
[b] Rod-shaped chert
[c] Tabular chert.
[d] All other Hillsborough River Quarry Cluster cherts combined.

Table 83 Multivariate classification of post-Archaic debitage assemblages controlled for raw-material type

Site/ Raw-Material Type	Discriminant Scores		Group Assignment	Probability of Correct Assignment
	Function 1	Function 2		
8GL13				
Cobbles	-8 4266	8.5500	Bipolar Core	1.0000
Hillsborough River QC	3.6597	3.6521	Tool	1.0000
Silicified Coral	.2326	1.3702	Core	.8163
Peace River	.3427	-.3316	Core	.6083
Non-chert Stone[a]	-1.0988	.5549	Core	.5631
8HG678				
Hillsborough River QC	-.2121	1.1030	Core	.9135
Peace River QC	-.6434	-.4879	Core	.6125
8HR48				
Hillsborough River QC	1.0749	-.3485	Tool	.6356
Peace River QC	.4859	-1.7932	Core	.8067
8PI1753				
Turtlecrawl Point, Type 1[b]	.2287	-1.7820	Core	.8344
Turtlecrawl Point, Type 2[c]	.2050	-1.0599	Core	.8937
Hillsborough River, Type 4	1.3028	1.1063	Tool	.8734
Hillsborough River QC[d]	1.3870	1.3625	Tool	.9168

[a] Dolomite, quartz, and fossil bone.
[b] Rod-shaped chert.
[c] Tabular chert.
[d] All other Hillsborough River Quarry Cluster cherts combined.

see Table 82). The general form of the curve, however, is most similar to those resulting from small-core reduction, which is reasonable given the small size of these chert "rods." The fact that the flakes of this raw material did not get classified by discriminant function as a "bipolar" assemblage is likely

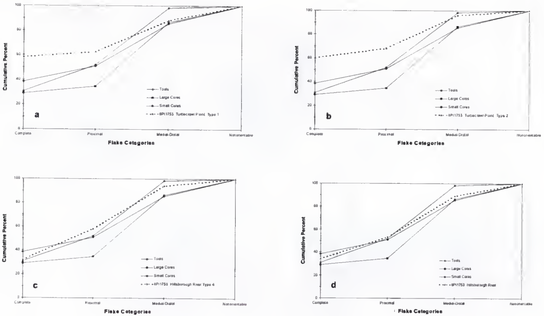


Figure 121. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for selected raw materials from 8Pl1753 with experimentally produced debitage assemblages: a) Turtlecrawl Point Quarry Cluster, Type 1; b) Turtlecrawl Point Quarry Cluster, Type 2; c) Hillsborough River Quarry Cluster Type 4; d) other Hillsborough Quarry Cluster cherts.

due to the comparatively small numbers of nonorientable fragments and medial-distal fragments relative to the experimental bipolar assemblages (cf. Chapter 8). Although no experiments were conducted to replicate the bipolar-core reduction of these chert rods, their small size (40-60 mm in length and no more than 10 mm in diameter) along with their small striking platforms, suggest that much of the flake shatter resulting from either direct or indirect percussion would have been too small to have been recovered in the 6.4 mm screens used during the excavation. The low number of proximal flake fragments (3, or 4.48 percent) is consistent with bipolar reduction, however (cf. Table 10).

The Type 2 variety of Turtlecrawl Point chert displays an Ogive curve that is similar to the Type 1 variety, but the number of nonorientable frag-ments is lower (Figure 121b). This has resulted in the right side of the curve approaching that of experimentally produced assemblages resulting from patterned-tool production. This assemblage is small (N=25) and may not be completely representative of the use of this material at the site.

The Type 4 variety of chert from the Hillsborough River Quarry Cluster was classified by discriminant analysis as likely resulting from patterned-tool production, as was the remaining Hillsborough River Quarry Cluster cherts, which consists of a variety of chert types from this quarry cluster that were not well enough represented to analyze separately. Although the probability of membership in the tool-reduction group is relatively high for both of these assemblages (.8734 and .9261, respectively), the Ogive curve for the Type 4 chert assemblage (Figure 121c) appears to be most similar to experimental assemblages resulting from small-core reduction while the Ogive curve for the other Hillsborough River cherts (Figure 121d) is more similar to the pat-terned-tool reduction curve. Examination of the bivariate plot of these two raw materials (not shown) indicates that they are positioned approximately midway between the group centroids for patterned-tool reduction and core-reduction, suggesting that they represent either mixed assemblages or early stage tool reduction. Both interpretations are supported by other artifacts in the assemblage. For example, 9 of the 21 hafted bifaces and bifacial preforms and 7 of the 18 cores and hammerstones recovered from Yat Kitischee were manufactured from these chert types (Appendix B). Thus, it seems highly likely that these raw materials were used for both patterned tool and core reduction at this site.

The discriminant analysis indicates that Peace River cherts at both 8HG678 and 8HR48 were used primarily in core-reduction. Both sites had very low numbers of proximal flakes and moderately high to high numbers of nonorientable fragments of this material (Table 83). Examination of the Ogive curves (Figure 122) indicates that there is a close similarity to experimental core-reduction assemblages. Although the probability for correct assignment for this material at 8HG678 is relatively low (p = .6125), the next likeliest assignment is the bipolar-core group, and the distribution of cumulative proportions for this material also approaches that of the experimental bipolar-core reduction assemblage (Figure 122a). The recovery of a core of Peace River chert from 8HR48 supports the interpretation of core reduction at this site (Appendix B).

Hillsborough River Quarry Cluster chert was classified by discriminant analysis as having been used in core reduction at 8HG678 and in patterned-tool reduction at 8HR48. The Ogive curves for this material support the discriminant analysis for 8HG678 (Figure 123a) but indicate that this material was used for both patterned-tool and core reduction at 8HR48 (Figure 123b). Comparison of the Ogive curve from 8HR48 with the data in Table 83 indicates that large numbers of complete flakes are present in this assemblage which results in the left-hand side of the curve approaching that of the experimental core-reduction assemblage. However, the right-hand side of the curve closely parallels the curve for the experimental tool reduction assemblage. The interpretation of a mixed assemblage for Hillsborough River cherts at 8HR48 is further supported by the low probability of correct assignment in the discriminant classification (Table 83) and the fact that the next highest group is the core-reduction group (p = 3644). Finally, the artifact assemblage from this site contains bifaces and a small core manufactured from Hillsborough River Quarry Cluster chert (Appendix B), further reinforcing the interpretation of a mixed flake assemblage.

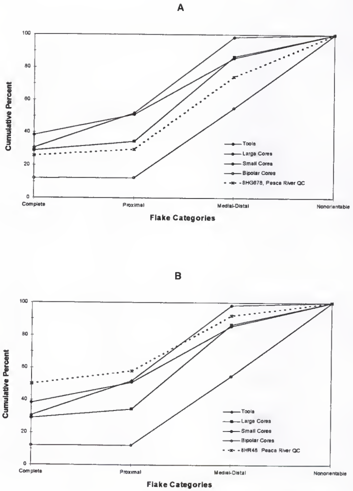


Figure 122. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Peace River Quarry Cluster cherts with experimentally produced debitage assemblages: a) 8HG678; b) 8HR48

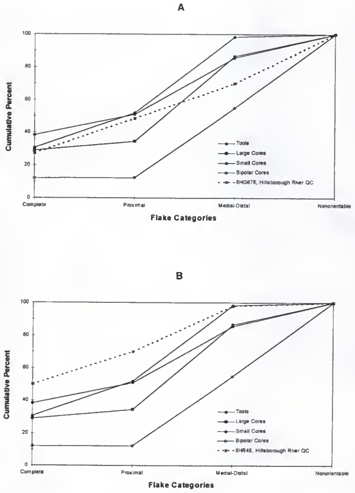


Figure 123. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Hillsborough River Quarry Cluster cherts with experimentally produced debitage assemblages: a)8HG678; b) 8HR48

The various raw-material types from Fort Center indicate that three different reduction strategies were prevalent (Table 83). Cobble material was classified by discriminant analysis as most similar to the experimental bipolar assemblage and the Ogive curve for this material also indicates a close similarity to bipolar reduction (Figure 124a). The recovery of 16 bipolar flakes provides additional support for this interpretation. Core reduction also is indicated by the Peace River Quarry Cluster, silicified coral, and the combined dolomite-quartz-fossil bone assemblages. The Ogive curves for these three raw-material categories support the discriminant classification quite well (Figure 124b-d). The combined assemblage of flakes of dolomite-quartz-fossil bone was included despite the low frequency (N=24) because I was interested to see how these local materials would be classified. The results indicate that the flake assemblage, which is dominated by nonorientable fragments, is very similar to the experimental bipolar-core assemblages. Although the discriminant analysis assigned this assemblage to the conventional core-reduction group (Table 83), the probability of membership was relatively low ($p = .5631$) and the second highest probability for membership was with the bipolar-core reduction group ($p = .405$). This also is reflected in the bivariate plot (not shown) where this assemblage is positioned intermediate between the core and bipolar-core centroids. The Peace River flake assemblage contains a comparatively large number of complete flakes which tends to lift the Ogive curve above that for small-core reduction (Figure 124b); otherwise the general form of the curve is similar to the curve resulting from small-core reduction. Although no cores of this raw material were recovered, four of the seven bifaces made from Peace River chert are Pinellas points. These small, triangular bifaces are the result of a production trajectory quite unlike that for larger hafted bifaces. Small flake blanks struck from a core were shaped into a roughly triangular form with minimal pressure retouch along the flake margins. Most of the debitage resulting from bifacial shaping would have been too small to be collected by conventional 6.4 mm screens, much less the 9.5 mm (3/8 inch) screens used by Sears during his excavations at Fort Center Thus, it seems reasonable that the debitage assemblage

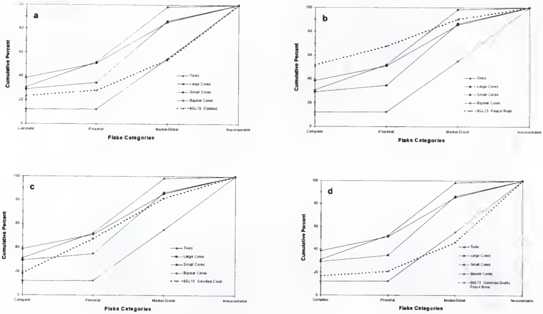


Figure 124. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for selected raw materials from 8GL13 with experimentally produced debitage assemblages: a) chert cobbles; b) Peace River Quarry Cluster; c) silicified coral; d) combined dolomite-quartz-fossil bone.

would reflect core reduction rather than biface reduction despite the comparatively high number of bifacial tools of this material in the assemblage

The classification of the silicified coral debitage as resulting from core reduction is the least satisfying of the three. The relatively acute mean striking platform angle (61.22 degrees for 19 complete platforms) and small size (28 of 38 flakes, or 73.68 percent, less than 2 cm in maximum dimension) along with a predominance of faceted platforms (13 of 19, 68.42 percent), prepared platforms (15 of 19, 78.95 percent), and diffuse bulbs of force (10 of 19, 52.6 percent), all indicate that most of this debitage is the result of late-stage biface reduction or tool maintenance. Furthermore, while there are no cores of this material in the assemblage, there are 23 bifaces (Appendix B).

Debitage from the Hillsborough River Quarry Cluster was classified as likely resulting from patterned-tool reduction (Table 83). When the Ogive curve is examined for this raw-material category, it appears to be more similar to the experimental small-core reduction than patterned-tool reduction curve (Figure 125). In addition to the size bias brought about by the use of a 9.5 mm screen, there is evidence to suggest that these cherts were subject to at least two different reduction strategies at Fort Center. A large number of bifaces made from Hillsborough River Quarry Cluster cherts (N=45) are present in the collection, including nine preforms. In addition, three cores and a hammer-stone are present. These data indicate that the discrepancy between the discriminant analysis and the Ogive curve is due in part to the mixed nature of the flake assemblage, although late-stage biface production and tool maintenance are believed to have been the dominant activities involving these cherts.

Flake-size Distribution

In order to test the interpretations of reduction strategies derived from the Sullivan-Rozen analysis, the flake-size distributions for each assemblage were compared to experimentally produced flake-size distributions following the procedures outlined in Chapter 8. The flake assemblages include utilized and modified flakes. The data are again presented first for the composite debitage assemblages

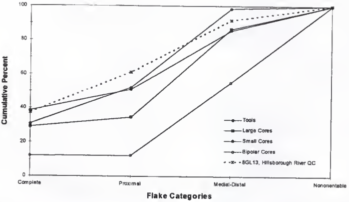


Figure 125. Comparison of the cumulative proportions of Sullivan-Rozen debitage categories for Hillsborough Quarry Cluster chert from 8GL13 with experimentally produced debitage assemblages.

from each site and then by raw-material types where possible. The raw data for the Archaic and post-Archaic assemblages are presented in Table 84.

Archaic assemblages As shown in Table 85, six of the ten Archaic assemblages are significantly different from the experimental core-reduction assemblages. Examination of Figures 126-131 shows the close correspondence between the flake-size distributions for these assemblages and the flake assemblage resulting from the experimental production of bifacial implements. The remaining four archaeological assemblages were found to be not significantly different from either the experimental core-reduction or biface-reduction assemblages. Examination of the actual distributions for three of these assemblages (8HG18, 8HG34, and 8HG767) indicates that their slopes are more like the biface-reduction slope except that in two cases (8HG34 and 8HG767) the archaeological assemblages are right-censored, with no flakes present in the size classes greater than 2-2.5 cm (Figures 132 and 133). The slope of the third assemblage (8HG18) is unduly influenced by a single, utilized

Table 84. Flake-size data for Archaic and post-Archaic assemblages. Totals include utilized and modified flakes.

Assemblages	Size Classes (cm)											
	<1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	>6	Totals
Archaic Assemblages													
8HG18	17	14	8							1			40
8HG20	13	6	3	2	1	1							26
8HG34	7	11	8	1									27
8HG35	21	21	7	3	3		1						56
8HG51	242	192	90	34	16	3	1	1	1	1			581
8HG678	11	22	8	1	2	2			1				47
8HG767	10	19	10	1	3								43
8HR68	74	110	54	22	5	3		1					269
8HR71	85	84	49	23	10	4	2	1					258
8HR92	199	145	57	48	24	10	5	2	3		1		494
Post-Archaic Assemblages													
8GL13	40	194	215	121	55	16	10	5		2	1	2	661
8HG18	27	41	15	2	2								87
8HG20	49	44	11	5	2	1							112
8HG27	33	15	9	10	2	1	1						71
8HG678	35	33	6	1	3	1							79

Table 84 (Continued)

Assemblages	Size Classes (cm)												
	<1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	>6	Totals
8HR44	84	45	21	9	6	4	2	2					173
8HR48	60	67	27	17	8	3	3						185
8LL33,36,37	34	19	12	11	6	4	1		3	1		1	92
8PI1753	67	92	80	52	24	16	11	6	8	1	1	2	360

Table 85. Results of ANOVA tests for equality of slopes between experimental and Archaic flake assemblages. Bold entries indicate rejection of the null hypothesis of no difference between slopes ($p \leq .05$).

Site	N	b	Experimental Core Assemblage b = -.58324			Experimental Biface Assemblage b = -1.15714		
			F	CV ∝ .05[a]	$b_i - b_{cores}$[b]	F	CV ∝ .05[a]	$b_i - b_{bifaces}$[b]
8HG18	40	-.7923	.864	$F_{(1,20)} = 4.35$	.2091	1.566	$F_{(1,17)} = 4.45$	.3648
8HG20	26	-1.0632	**5.784**	**$F_{(1,16)} = 4.49$**	.4799	.216	$F_{(1,13)} = 4.67$	.0940
8HG34	27	-1.2312	1.819	$F_{(1,14)} = 4.60$	.6480	.022	$F_{(1,11)} = 4.84$	.0741
8HG35	56	-1.2307	**12.213**	**$F_{(1,17)} = 4.45$**	.6474	.132	$F_{(1,14)} = 4.60$	.0735
8HG51	581	-1.1922	**11.135**	**$F_{(1,20)} = 4.35$**	.6089	.023	$F_{(1,17)} = 4.45$	.0350
8HG678	47	-.8702	2.557	$F_{(1,19)} = 4.38$	.2869	1.710	$F_{(1,16)} = 4.49$	.2870
8HG767	42	-1.0943	2.672	$F_{(1,15)} = 4.54$	.5111	.037	$F_{(1,12)} = 4.75$	.0629
8HR68	269	-1.4009	**27.180**	**$F_{(1,18)} = 4.41$**	.8176	1.893	$F_{(1,15)} = 4.54$	.2437
8HR71	258	-1.3842	**33.941**	**$F_{(1,18)} = 4.41$**	.8010	2.301	$F_{(1,15)} = 4.54$	.2271
8HR92	494	-1.0317	**14.138**	**$F_{(1,21)} = 4.32$**	.4484	.695	$F_{(1,18)} = 4.41$	.1255

[a] Critical values of F at an alpha level of .05.

[b] Absolute difference between slopes of experimental and archaeological assemblages.

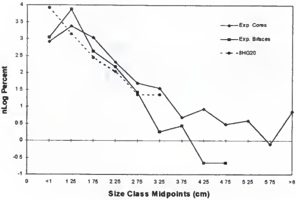


Figure 126. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the Archaic assemblage at 8HG20.

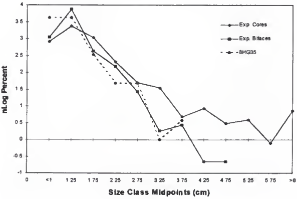


Figure 127. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HG35.

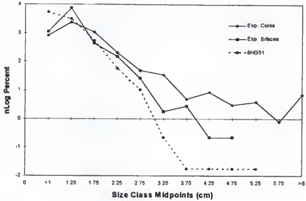


Figure 128. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HG51.

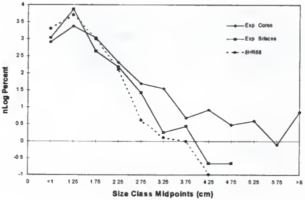


Figure 129. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HR68.

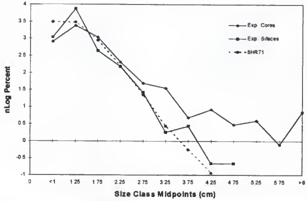


Figure 130. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HR71.

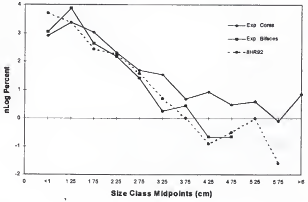


Figure 131. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HR92.

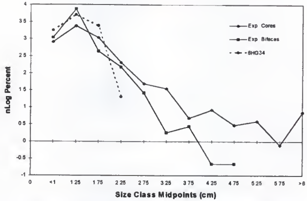


Figure 132. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the Archaic assemblage at 8HG34.

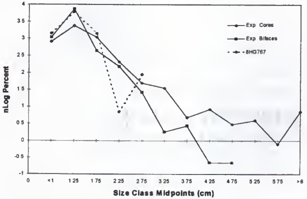


Figure 133. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HG767.

flake in the 5-5.5 cm size class (Figure 134). Without this flake, the entire debitage assemblage is contained in size classes measuring less than 2 cm in maximum dimension.

The three flake assemblages from the Kissimmee River sites (8HG18, 8HG20, and 8HG34) were combined along with three flakes from the Archaic levels at 8HG27 (2 flakes in the 1-1.5 cm class, 1 flake in the 2-2.5 cm class) to form a composite flake assemblage. Figure 135 shows that the left side of the slope of this composite assemblage is much more like the experimental biface-reduction assemblage than the core-reduction assemblage; however, the presence of the large utilized flake in the 5-5.5 cm size class has affected the right side of the slope dramatically. This has resulted in ANOVA calculations that indicate that the archaeological assemblage is not significantly different from either the experimental biface-reduction assemblage or the core-reduction assemblage (Table 86). When this flake is removed and the resulting flake-size distribution is reanalyzed, the ANOVA results indicate significant differences between both the experimental tool and core-reduction assemblages. This appears to be due to the large number of flakes in the smallest size class when compared to the experimental assemblages, which pulls the left side of the distribution curve upwards, and the low number of flakes in the second to the largest size class represented in this assemblage (2-2.5 cm), which pulls the right side of the distribution curve downwards. However, the steepness of the actual slope value (*b*) strongly suggests that the assemblage is primarily the result of biface reduction and maintenance. The latter activity would account for the greater number of flakes in the small size class. The higher *F* value and the larger absolute difference between the archaeological assemblage and the experimental core-reduction assemblage also supports this interpretation (Table 86). Finally, flake-platform attributes are suggestive of biface reduction. For example, the mean striking platform angle of 68.56 degrees for 48 measurable platforms is relatively acute. The majority of the platforms exhibit multiple facets (29 of 50, or 58 percent)as well as evidence of edge preparation (32 of 50 platforms, or 64 percent) and ventral lipping (29 of 50, or 58 percent). Half of the 50 platform-bearing flakes also exhibit diffuse bulbs of force.

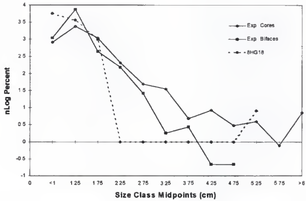


Figure 134. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the Archaic assemblage at 8HG18.

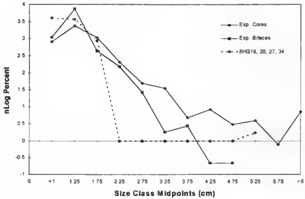


Figure 135. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the composite Archaic assemblage from 8HG18, 8HG20, 8HG27, and 8HG34.

Table 86. Results of ANOVA tests for equality of slopes between experimental and composite Archaic and post-Archaic flake assemblages from 8HG18, 8HG20, 8HG27, and 8HG34.

Site	N	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
			F	CV ∝ .05[a]	$b_1 - b_{cores}$[b]	F	CV ∝ .05[a]	$b_1 - b_{bifaces}$[b]
Archaic	96	-.9269	4.070	$F_{(1,20)} = 4.35$	.3436	1.134	$F_{(1,17)} = 4.45$	.2303
Archaic[c]	95	-1.7201	**24.006**	$\mathbf{F_{(1,16)} = 4.49}$	1.1369	**5.222**	$\mathbf{F_{(1,13)} = 4.67}$	.5630
Post-Archaic	277	-1.690	**45.508**	$\mathbf{F_{(1,17)} = 4.45}$	1.1070	**9.521**	$\mathbf{F_{(1,14)} = 4.60}$	.5331

[a] Critical values of F at an alpha level of .05.

[b] Absolute difference between slopes of experimental and archaeological assemblages.

[c] Archaic assemblage minus one large utilized flake.

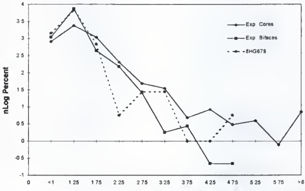


Figure 136. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the Archaic assemblage at 8HG678.

The flake-size distribution from 8HG678 is shown in Figure 136. Although the smaller flake-size classes exhibit a slope that is more similar to the experimental biface-reduction slope, the right-hand side of the slope (i.e., the larger flake-size classes) is very irregular with some size-classes approaching values similar to the experimental core-reduction slope.

Table 87 provides the raw flake-size data for various raw materials from selected Archaic assemblages. The ANOVA results comparing these distributions to the experimental flake-size distributions are presented in Table 88. Figures 137-142 show the flake-size distributions for various raw materials from 8HG51, 8HR68, 8HR71, and 8HR92. The results generally mirror those of the Sullivan-Rozen analysis (Table 80): most raw materials were used primarily in the production or maintenance of patterned tools, probably hafted bifaces. Some minor core reduction probably also occurred as indicated by the presence of a few small cores at some sites (Appendix A); however, the close correspondence between the results of the two debitage analyses suggests that core-reduction did

Table 87. Flake-size data for selected Archaic assemblages controlled for raw-material type. Totals include utilized and modified flakes

Assemblages/ Raw Materials	Size Classes (cm)												
	<1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	>6	Totals
8HG51													
Hillsborough River QC	17	17	21	4	3		1						63
Peace River QC	174	137	47	24	12	1		1		1			397
Withlacoochee QC	11	9	7	2									29
Silicified Coral	28	19	7	3		1			1				59
8HR68													
Hillsborough River QC[a]	47	69	35	14	4	2							171
Cow House Creek	5	11	6	3		1		1					27
8HR71													
Hillsborough River QC	52	44	26	9	6	2	1	1					141
Withlacoochee QC	16	20	12	7	1	2							58
Silicified Coral	8	6	6	4	1								25

Table 87 (Continued).

Assemblages/ Raw Materials	Size Classes (cm)												
	<1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	>6	Totals
8HR92													
Hillsborough River QC[b]	89	68	23	19	10	2		2	1		1		215
Cow House Creek	13	9	10	6	2	2	1		1				44
Bay Bottom	12	8	1	4		1							26
Withlacoochee QC	25	20	6	3	4	2							60
Silicified Coral	29	14	8	9	3	1	4		1				69

[a] All Hillsborough River Quarry Cluster cherts except Cow House Creek.

[b] All Hillsborough River Quarry Cluster cherts except Cow House Creek and Bay Bottom.

Table 88 Comparison of ANOVA results for equality of slopes between experimental flake assemblages and archaeological flake assemblages. Bold entries indicate rejection of the null hypothesis of no difference between slopes ($p \leq .05$).

Assemblage/ Raw Material	N	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
			F	CV ∝ .05^a	$b_i - b_{cores}$^{b}	F	CV ∝ .05^a	$b_i - b_{bifaces}$^{b}
8HG51								
Hillsborough River QC	63	-1.2169	**9.760**	**$F_{(1,17)} = 4.45$**	.6336	1.070	$F_{(1,14)} = 4.60$	.0597
Peace River QC	397	-1.1922	**11.135**	**$F_{(1,20)} = 4.35$**	.6089	.023	$F_{(1,17)} = 4.45$	.0350
Withlacoochee QC	29	-1.0731	1.576	$F_{(1,14)} = 4.60$	.4899	.047	$F_{(1,11)} = 4.84$	.0840
Silicified Coral	59	-.9930	**5.260**	**$F_{(1,19)} = 4.38$**	.4098	.565	$F_{(1,16)} = 4.49$	.1641
8HR68								
Hillsborough River QC^c	178	-1.4462	**13.384**	**$F_{(1,16)} = 4.49$**	.8630	1.321	$F_{(1,13)} = 4.67$	.2891
Cow House Creek	27	-.8949	1.833	$F_{(1,18)} = 4.41$	.3116	.903	$F_{(1,15)} = 4.54$	.2623
8HR71								
Hillsborough River QC	141	-1.3019	**26.891**	**$F_{(1,18)} = 4.41$**	.7187	.916	$F_{(1,15)} = 4.54$	.1448
Withlacoochee QC	58	-1.1385	**4.916**	**$F_{(1,16)} = 4.49$**	.5552	.048	$F_{(1,13)} = 4.67$	.0887
Silicified Coral	25	-.9129	1.314	$F_{(1,15)} = 4.54$	.3296	.694	$F_{(1,12)} = 4.75$	.2443
8HR92								

Table 88 (Continued).

Assemblage/ Raw Material	N	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
			F	CV $\propto$ .05[a]	$b_i - b_{cores}$[b]	F	CV $\propto$ .05[a]	$b_i - b_{bifaces}$[b]
Hillsborough River QC[d]	215	-.9401	**7.636**	**$F_{(1,21)} = 4.32$**	.3569	1.730	$F_{(1,18)} = 4.41$	.2171
Cow House Creek	44	-.8339	3.594	$F_{(1,19)} = 4.38$	.2507	4.436	$F_{(1,16)} = 4.49$	.3232
Bay Bottom	26	-1.2182	3.890	$F_{(1,16)} = 4.49$	.6349	.028	$F_{(1,13)} = 4.67$	.0610
Withlacoochee QC	60	-1.0372	**4.504**	**$F_{(1,16)} = 4.49$**	.4539	.293	$F_{(1,13)} = 4.67$	.1200
Silicified Coral	69	-.8694	3.607	$F_{(1,19)} = 4.38$	.2862	2.564	$F_{(1,16)} = 4.49$	.2877

[a] Critical values of F at an alpha level of .05.
[b] Absolute difference between slopes of experimental and archaeological assemblages.
[c] All Hillsborough River Quarry Cluster cherts except Cow House Creek.
[d] All Hillsborough River Quarry Cluster cherts except Cow House Creek and Bay Bottom.

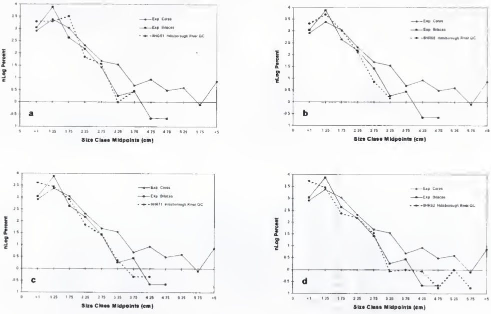


Figure 137. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Hillsborough River Quarry Cluster cherts: a) 8HG51; b) 8HR68; c) 8HR71; d) 8HR92.

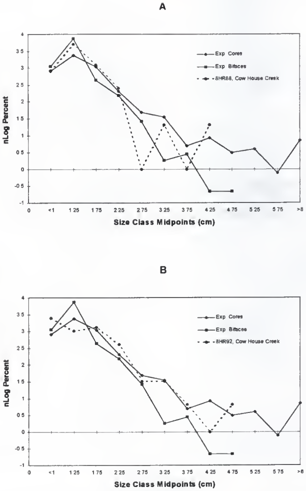


Figure 138. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Cow House Creek chert: a) 8HR68; b) 8HR92.

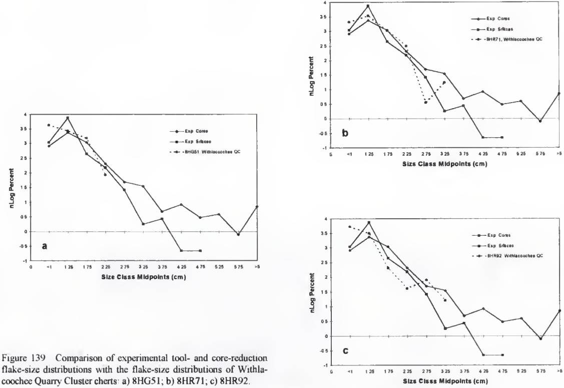


Figure 139 Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Withlacoochee Quarry Cluster cherts: a) 8HG51; b) 8HR71; c) 8HR92.

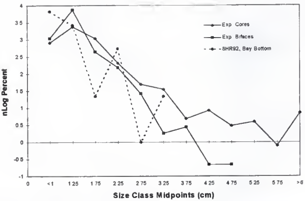


Figure 140. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Bay Bottom chert from 8HR92.

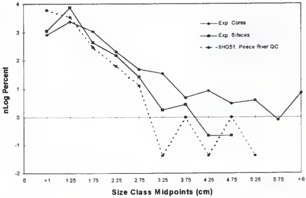


Figure 141 Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Peace River Quarry Cluster chert from 8HG51.

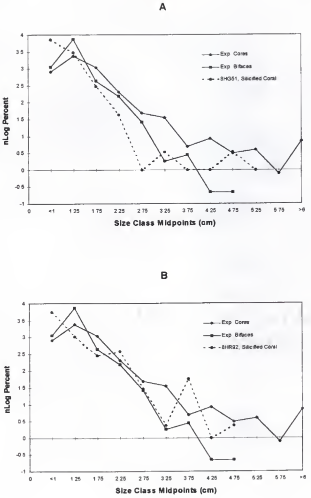


Figure 142. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of silicified coral: a) 8HG51; b) 8HR92.

not contribute greatly to the formation of these Archaic waste-flake assemblages. A few raw materials, notably chert from the Cow House Creek region of the Hillsborough River Quarry Cluster, appear to have been used primarily for core reduction, although early-stage biface reduction could have produced similar flake-size distributions (see Chapter 8). The only raw material that produced different results was silicified coral at 8HR92. This material was classified by discriminant analysis as having been the result of patterned-tool reduction, but the flake-size analysis suggests that core reduction occurred (Table 87). Comparison of the flake-size distribution of this raw material with those of experimental biface- and core-reduction assemblages indicates that the slope for silicified coral at 8HR92 is most similar to the core-reduction assemblage (Figure 142b), but this is partly due to the large number of flakes in the smallest size class as well as a certain amount of irregularity in the larger size classes. Other waste-flake attributes such as the relatively acute mean striking-platform angle (63.61 for 38 complete platforms), the high incidence of faceted (24 of 38, or 63.16 percent) and prepared (23 of 38, or 60.53 percent) platforms, and the prevalence of diffuse bulbs of force (23 of 38, or 60.53 percent) indicate that most of these flakes are the result of late-stage biface reduction or maintenance. The large number of flakes that exhibit evidence of thermal alteration (54 of 69, or 78.26 percent) supports this interpretation.

Post-Archaic assemblages. With a single exception, all of the flake-size distributions for the composite post-Archaic assemblages were determined to be significantly different from the experimentally produced core-reduction assemblage (Table 89). The exception is Pineland (8LL33, 36, 37) which was classified as being most similar to the experimental core-reduction distribution. Examination of Figure 143 indicates that the slope of the distribution for this assemblage is nearly parallel with the experimental core-reduction assemblage. The fact that there are comparatively more flakes in the smallest size class (< 1 cm) than are represented in the experimental assemblage suggests that the sizes of the cores imported to this site were themselves relatively small. These results are

Table 89. Results of ANOVA tests for equality of slopes between experimental and Archaic flake assemblages. Bold entries indicate rejection of the null hypothesis of no difference between slopes ($p \leq .05$).

Site	N	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
			F	CV ∝ .05[a]	$b_i - b_{cores}$[b]	F	CV ∝ .05[a]	$b_i - b_{bifaces}$[b]
8HG18	88	-1.4830	**7.208**	**$F_{(1,15)} = 4.54$**	.8997	.840	$F_{(1,12)} = 4.75$	.3258
8HG20	112	-1.6869	**29.671**	**$F_{(1,16)} = 4.49$**	1.1037	**6.591**	**$F_{(1,13)} = 4.67$**	.5297
8HG27	71	-1.3809	**17.954**	**$F_{(1,17)} = 4.45$**	.7976	1.271	$F_{(1,14)} = 4.60$	.2237
8HG678	79	-1.5293	**11.557**	**$F_{(1,16)} = 4.49$**	.9460	1.471	$F_{(1,13)} = 4.67$	.3721
8HR44	173	-1.2261	**15.937**	**$F_{(1,18)} = 4.41$**	.6429	.059	$F_{(1,15)} = 4.54$	.0690
8HR48	185	-1.1725	**12.716**	**$F_{(1,17)} = 4.45$**	.5893	.008	$F_{(1,14)} = 4.60$	.0154
8LL33,36, 37	92	-.6779	.668	$F_{(1,22)} = 4.30$	.0947	**10.038**	**$F_{(1,19)} = 4.38$**	.4792
8PI1753	360	-.8664	**6.244**	**$F_{(1,22)} = 4.30$**	.2831	3.891	$F_{(1,19)} = 4.38$	.2908

[a] Critical values of F at an alpha level of .05.
[b] Absolute difference between slopes of experimental and archaeological assemblages.

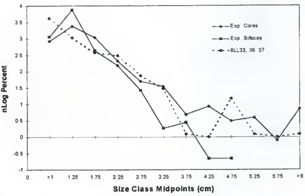


Figure 143. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8LL33, 36, 37.

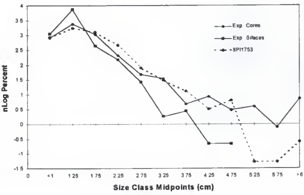


Figure 144 Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8PI1753.

consistent with those derived from the Sullivan-Rozen analysis (Table 81), as well as the analysis of other flake attributes (Austin 1995a).

The flake-size distribution for Yat Kitischee (8PI1753) appears nearly identical visually to the experimental core-reduction assemblage (Figure 144), yet the slope value of -.8664 is almost equally distant from the two experimental slope values (Table 89), suggesting a mixed assemblage. Examination of the log-linear distribution for this assemblage indicates that the three largest flake-size classes contain fewer flakes than the experimental core-reduction assemblage which would affect the right tail of the slope, pulling it away from the core-reduction curve and towards the biface-reduction curve.

The distributions for the remaining sites all appear visually to be most similar to the slope of the experimental biface-reduction assemblage with 8HG18, 8HG20, 8HG27, 8HR44, and 8HR48 being the most similar (Figures 145-149). The composite flake assemblage for the Kissimmee River sites (8HG18, 8HG20, 8HG27, and seven flakes from the post-Archaic component at 8HG34: 4 in the .5-1 cm class and one each in the 1-1.5 cm, 1.5-2 cm, and 2.5-3 cm classes) is even more similar to the experimental biface slope than the individual sites (Figure 150). While the ANOVA test indicates that this composite assemblage is significantly different from both the biface- and core-reduction assemblages (Table 86), other flake attributes support the interpretation that the debitage is the result of biface reduction. Exterior striking-platform angle is acute (65.18 degrees for 166 measurable plat-forms), and the assemblage is dominated by faceted (93, or 56.02 percent), prepared (113, or 68.07 percent), and lipped (97, or 58.43 percent) platforms and diffuse bulbs of force (90, or 54.22 percent). The Blueberry site (8HG678) also has a relatively steep slope, although there is some irregularity on the right side of the distribution (Figure 151).

Tables 90 and 91 provide flake-size data for selected raw materials from three post-Archaic assemblages -- 8HG678, 8HR48, and 8PI1753. In the Yat Kitischee (8PI1753) assemblage, six of the seven raw-material types have slopes that are significantly different from the biface-reduction assemblage and the seventh (the rod-shaped Turtlecrawl Point chert) is intermediate between tools and cores

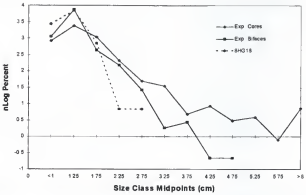


Figure 145. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the post-Archaic assemblage at 8HG18.

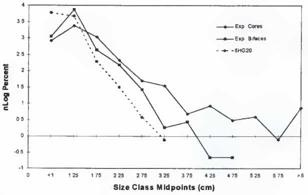


Figure 146. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the post-Archaic assemblage at 8HG20.

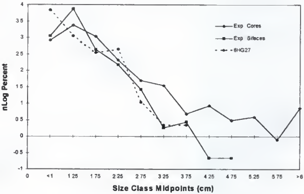


Figure 147. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the post-Archaic assemblage at 8HG27.

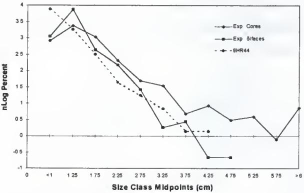


Figure 148. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HR44.

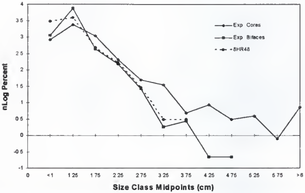


Figure 149. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from 8HR48.

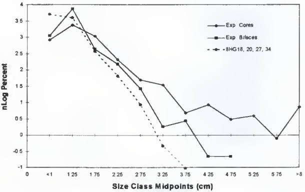


Figure 150. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the composite post-Archaic assemblage from 8HG18, 8HG20, 8HG27, and 8HG34.

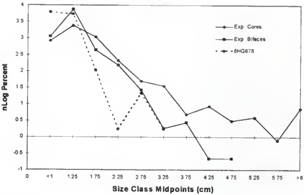


Figure 151. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distribution from the post-Archaic assemblage at 8HG678.

(Table 91). Visual examination of the log-linear distributions for these raw-material types indicates that the Type 1, Turtlecrawl Point chert debitage exhibits a distribution curve that closely parallels the core-reduction curve except for the 3-3.5 cm size class (Figure 152a). As a result, the slope of the regression line is steeper than might be expected given the distribution of flakes between the other size classes. Even though this assemblage was not statistically different from either the core-reduction or biface-reduction assemblages, the calculated difference between the slope value for this raw material and the experimental biface assemblage is .4027 while the difference between it and the core-reduction assemblage is only .1712. The *F* value comparing the Yat Kitischee assemblage to the biface-reduction assemblage is nearly four times as large as the *F* value between this assemblage and the core-reduction assemblage. All of these observations indicate that the rod-shaped, Turtlecrawl Point assemblage is best interpreted as the result of core reduction, an interpretation that is consistent with the Sullivan-Rozen analysis and is supported by the number of cores and bipolar flakes in the assemblage. The high

Table 90. Flake-size data for selected post-Archaic assemblages controlled for raw-material type. Totals include utilized and modified flakes

Assemblages/ Raw Materials	Size Classes (cm)											
	<1	1-1.5	1.5-2	2-2.5	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	>6	Totals
8HG678													
Hillsborough River QC	13	15	4	1									33
Peace River QC	11	12	2		2								27
8HR48													
Hillsborough River QC	12	23	6	7	2	2	1						53
Peace River QC	25	25	13	5	5	1	2						76
8PI1753													
Turtlecrawl Point, Type 1[a]	13	25	12	9	3		1	2	2				67
Turtlecrawl Point, Type 2[b]	4	5	5	7	3	1							25
Hillsborough River, Type 4	13	7	24	12	4	4	2	1	1				69
Hillsborough River QC[c]	32	37	25	15	9	3	4	1	2		1	1	130

[a] Rod-shaped chert.
[b] Tabular chert.
[c] All other Hillsborough River Quarry Cluster cherts combined.

Table 91. Results of ANOVA tests for equality of slopes between experimental and selected post-Archaic flake assemblages controlled for raw material. Bold entries indicate rejection of the null hypothesis of no difference between slopes ($p \leq .05$).

Site	N	b	Experimental Core Assemblage $b = -.58324$			Experimental Biface Assemblage $b = -1.15714$		
			F	CV α .05[a]	$b_i - b_{cores}$ [b]	F	CV α .05[a]	$b_i - b_{bifaces}$ [b]
8HG678								
Hillsborough River QC	33	-1.8033	**8.576**	**$F_{(1,14)} = 4.60$**	1.2201	2.355	$F_{(1,11)} = 4.84$	.6462
Peace River QC	27	-1.4408	3.822	$F_{(1,15)} = 4.54$	.8575	.341	$F_{(1,12)} = 4.75$	.2836
8HR48								
Hillsborough River QC	53	-.9599	4.309	$F_{(1,17)} = 4.45$	.3766	1.004	$F_{(1,14)} = 4.60$	.1973
Peace River QC	76	-1.0693	**6.949**	**$F_{(1,17)} = 4.45$**	.4861	.191	$F_{(1,14)} = 4.60$	.0878
8PI1753								
Turtlecrawl Point, Type 1[c]	67	-.7544	.907	$F_{(1,19)} = 4.38$	.1712	3.356	$F_{(1,16)} = 4.49$	.4027
Turtlecrawl Point, Type 2[d]	25	-.4644	.241	$F_{(1,16)} = 4.49$	.1188	**7.123**	**$F_{(1,13)} = 4.67$**	.6927
Hillsborough River, Type 4	69	-.7011	1.098	$F_{(1,22)} = 4.30$	.1179	**9.726**	**$F_{(1,19)} = 4.38$**	.4560
Hillsborough River QC[e]	130	-.7531	2.659	$F_{(1,22)} = 4.30$	.1699	**9.147**	**$F_{(1,19)} = 4.38$**	.4040

[a] Critical values of F at an alpha level of .05.
[b] Absolute difference between slopes of experimental and archaeological assemblages.
[c] Rod-shaped chert.
[d] Tabular chert.
[e] All other Hillsborough River Quarry Cluster cherts.

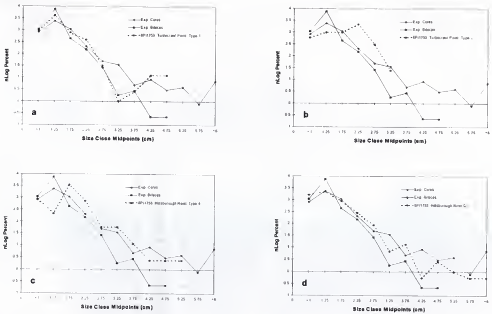


Figure 152. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of selected raw materials from 8PI1753: a) Turtlecrawl Point, Type 1; b) Turtlecrawl Point, Type 2; c) Hillsborough River Quarry Cluster, Type 4; d) all other Hillsborough River Quarry Cluster cherts combined.

striking-platform angle for this material (78.94 degrees for 16 measurable platforms) along with the large number of cortex-covered (11 of 42, 26.19 percent) and point platforms (24 of 42, 57.14 percent) are further evidence supporting the conclusion that this raw material was used principally for bipolar-core reduction.

The Type 2 variety of Turtlecrawl Point chert and the Type 4 Hillsborough River chert exhibit distributions that suggest that they represent a mix of core and biface reduction (Figure 152b, c). The numbers of flakes in the 2-3 cm size range are greater than expected in the first assemblage when compared to the experimental assemblages and the numbers of flakes in the 1.5-2.5 cm size range are greater than expected in the second assemblage. The recovery of two bifaces, a core, and a hammerstone of Type 4 material (Appendix B) provides strong supporting evidence for interpreting this material as having been used in both biface and core reduction.

The last raw-material category at Yat Kitischee that contained enough flakes to plot was the composite Hillsborough River Quarry Cluster cherts, minus the Type 4 variety (Figure 152d). This distribution appears most similar to the core-reduction curve, and while a core made from this material was recovered from the site, there also are four bifaces. Thus, the curve may reflect early-stage biface reduction or a mixed biface-reduction and core-reduction assemblage. The mix of flake platform attributes seems to confirm this. Striking-platform angle is moderately high (68.93 degrees for 66 measurable platforms) and the most common characteristics are flat, or single-facet, platforms (41 of 68 complete platforms, or 60.29 percent), unprepared platforms (41, or 60. 29 percent), and pronounced bulbs of force (40, or 58.82 percent). However, faceted , prepared platforms with moderate to diffuse bulbs of force also are present in appreciable numbers (21, or 30.89 percent; 27, or 39.71 percent; and 38,or 55.88 percent, respectively).

The slope values for Hillsborough River and Peace River cherts at 8HG678 are both quite high and the slope for Hillsborough River cherts was determined to be statistically different from the experimental core-reduction assemblage by the ANOVA analysis (Table 91). These results are completely at odds with those of the Sullivan-Rozen analysis (Table 82) which indicated that both raw materials were used primarily for core reduction. Since seven of the 12 bifaces in this assemblage are manufactured from Hillsborough River cherts, and there are no cores of this material in the assemblage, it would seem that the flake-size analysis is more correct. Analysis of other debitage attributes supports this interpretation. Mean striking-platform angle is relatively acute (67 degrees for 16 measurable platforms) and platform architecture is typified by a high degree of edge preparation and platform faceting (14 of 16 prepared platforms, 87.5 percent; 11 of 16 faceted platforms, 68.75 percent), all of which are characteristic of biface reduction. On the other hand, Peace River debitage is characterized by a more obtuse mean striking-platform angle (72.22 degrees for 9 complete platforms) and fewer prepared and faceted platforms (1 of 9 prepared platforms, 11.11 percent; 3 of 9 faceted platforms, 33.33 percent) which supports an interpretation of core reduction for this material. I believe the contradictory results of the flake-size and Sullivan-Rozen analyses are due to the small sizes of the flakes in this assemblage (Figures 153a and 154a), which are a reflection of package size. Bifaces appear to have entered the site as late-stage preforms or finished implements while cores entered the site as small chert nuclei.

Contradictory results also are evident for Hillsborough River and Peace River cherts from 8HR48 (cf. Tables 82 and 91). The flake-size analysis indicates that the slope of the flake-size distribution for Hillsborough River cherts is not significantly different from either the experimental core-reduction or the experimental biface-reduction assemblages, but the Sullivan-Rozen analysis indicated that flakes of this material were the result of patterned-tool reduction. The flake-size slope of the Peace River debitage was determined to be significantly different from the experimental core-reduction slope, yet the Sullivan-Rozen analysis indicated that this material was primarily the result of core reduction. Bifaces and cores of both materials are present in the assemblage of 8HR48 (Appendix

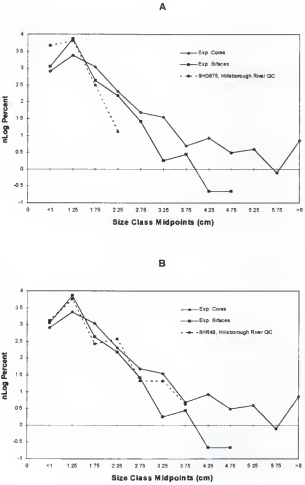


Figure 153. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Hillsborough River Quarry Cluster cherts from selected post-Archaic sites: a) 8HG678; b) 8HR48.

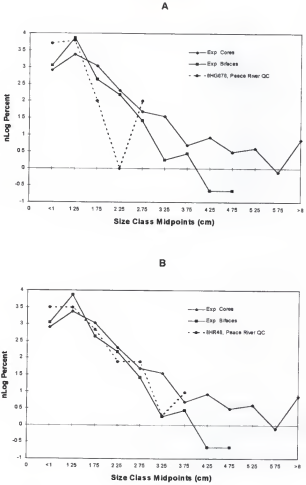


Figure 154. Comparison of experimental tool- and core-reduction flake-size distributions with the flake-size distributions of Peace River Quarry Cluster cherts from selected post-Archaic sites: a) 8HG678, b) 8HR48.

B), and in similar numbers. Furthermore, mean striking-platform angles are nearly identical for the two raw materials and both are relatively acute (Hillsborough River: 65.03 degrees for 35 measurable platforms; Peace River: 68.73 degrees for 45 measurable platforms). However, differences are apparent in the number of prepared and faceted platforms among the two raw materials. Flakes of Hillsborough River chert display these two attributes more frequently (22 of 35 faceted platforms, 62.86 percent; 18 of 35 prepared platforms, 51.43 percent) than Peace River debitage (15 of 45 faceted platforms, 33.33 percent; 14 of 45 prepared platforms, 31.11 percent). These differences could be reflective of different technologies, but the uniformly low mean striking-platform angles suggests that both debitage assemblages are primarily the result of biface rather than core reduction. The differences in striking-platform architecture are probably the result of local Peace River materials entering the site in an earlier stage than the non-local Hillsborough River cherts. Comparison of the flake-size distributions of the two materials would tend to support this interpretation since the slope for Peace River cherts is flatter than that for the Hillsborough River cherts (Figures 153b and 154b).

Fort Center

The flake-size distribution for Fort Center (8GL13) could not be compared in the same way as the other archaeological assemblages because of the size bias introduced through the use of 9.5 mm (3/8 inch) screens during excavation. This bias is clearly indicated by the very low number of flakes in the smallest size class (40, or 6.05 percent) in this assemblage in comparison to the other archaeological assemblages Attempts to adjust the experimental flake-size data by deleting the smallest size class and then recalculating percentages, natural logarithms, and slope values before statistical and visual comparisons were made with the archaeological assemblage did not produce satisfactory results. This is probably because the smallest flake sizes, which appear to be the most diagnostic of biface production and particularly late-stage reduction activities, were not included in the analysis For these

Table 92. Flake attributes for selected raw materials from Fort Center (8GL13).

Flake Attributes	Peace River QC		Hillsborough River QC		Cobbles		Silicified Coral	
	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Totals	21		116		78		18	
Mean Platform Angle	72.48		66.10		77.24		61.22	
Platform Condition								
Cortex	1	4.76	7	6.03	25	32.05	0	.00
Flat (Single Facet)	12	57.14	49	42.24	25	32.05	5	27.78
Multiple Facets	8	38.10	54	46.55	4	5.13	13	72.22
Point	0	.00	6	5.17	24	30.77	0	.00
Platform Preparation								
Prepared	8	28.57	70	60.34	12	15.38	15	83.33
Unprepared	13	61.90	46	39.66	66	84.62	3	16.67
Platform Lipping								
Lip	6	28.57	62	53.45	5	6.41	12	66.67
No Lip	15	71.43	54	46.55	73	93.59	6	33.33
Bulb of Force								
Diffuse	7	33.33	70	60.34	44	56.41	10	55.56
Moderate	5	23.81	32	27.59	18	23.08	5	27.78
Pronounced	9	42.86	14	12.07	16	20.51	3	16.67

reasons, I did not include the Fort Center flakes in the flake-size analysis. However, other flake attributes provide a means of validating the Sullivan-Rozen analysis (Table 92).

Looking first at the two raw materials that exhibit the most obvious differences -- silicified coral and the chert cobbles -- there is a clear difference in platform architecture with the chert cobbles exhibiting an abundance of unprepared, cortex-covered and "point" platforms, while the silicified coral flakes display predominately prepared and faceted platforms. Exterior platform angle is significantly lower among silicified coral flakes and platform lipping is more common indicating use of a soft-hammer during late-stage flake removal. These combinations of flake attributes reflect core reduction and late-stage biface reduction for the cobbles and silicified coral, respectively. While the core reduction interpretation for the cobbles is consistent with the Sullivan-Rozen analysis, late-stage biface reduction for silicified coral is not. As discussed previously, the large number of silicified coral bifaces, the absence of any cores of this material, and the high occurrence of thermal alteration among silicified coral bifaces and debitage, all indicate that silicified coral debitage was indeed the result of late-stage biface reduction or tool maintenance.

Hillsborough River Quarry Cluster chert was classified by the discriminant analysis as resulting from patterned-tool production, but the Ogive curves indicated a closer resemblance to small-core reduction. The flake attributes in Table 92 suggest that both may have contributed to this flake assemblage, although the moderately low mean platform angle along with the dominance of prepared platforms and diffuse bulbs of force suggest that biface reduction may have been more dominant. The relatively large number of flat, or single-facet, platforms and the equally abundant number of unlipped platforms may be the result of the reduction of early-to-middle-stage bifacial preforms as well as cores. Bifaces, including finished implements and production rejects, along with a few small cores, are all present in the Fort Center assemblage (Appendices B and C) supporting the interpretation of a mixed assemblage of waste flakes.

Finally, the dominance of flat, unprepared platforms with no lips and moderate to pronounced bulbs of force are consistent with the interpretation of small-core reduction for Peace River cherts that was indicated by the Sullivan-Rozen analysis. The relatively high striking-platform angle also supports this interpretation.

Summary

While the flake-size data generally support the Sullivan-Rozen analysis for Archaic assemblages, the two analyses produce somewhat conflicting results for the post-Archaic assemblages. I believe this is a reflection of greater technological variability during the post-Archaic than during the earlier Archaic period, which is characterized by a high degree of tech-nological uniformity. The reduction of bifacial implements, primarily late-stage preforms, and the maintenance of worn bifaces appear to be a technological hallmark of the Archaic period. Core reduction did occur, as evidenced by the presence of a few small, discarded cores; however, this technological activity does not seem to have been a major one. On the other hand, post-Archaic assemblages contain a greater mix of biface-reduction and core-reduction debitage which has resulted in many of the assemblages being classified as mixed. Bifaces still seem to have entered most sites as late-stage preforms or finished implements, although where local raw materials are present, such as in the Peace River valley or at Yat Kitischee, some early-stage bifaces may have been imported. Most cores in the Archaic and post-Archaic assemblages also were small, no doubt reflecting the cost of importing these materials from great distances, but core-reduction seems to have been relied on to a greater extent during the post-Archaic period.

Conclusion

With regard to the strategies of resource maximization or time minimization, the results of the analyses presented in this chapter present results that contradict many of the expectations expressed in Chapter 6. For example, neither the Archaic nor the post-Archaic assemblages exhibit high tool diversity. Moreover, while most individual specimens do not display overwhelming evidence for use in multiple tasks, several tool classes, notably bifaces and flake tools, are associated with a wide range of functional tasks. Thus, it would appear that none of the assemblages are particularly specialized.

Only three tool classes are associated with restricted numbers of tasks at both the specimen and class levels: microliths, unifaces, and hammerstones. Microliths and hammerstones are strongly associated with post-Archaic assemblages. Hammerstones appear at only three sites: Fort Center, Pineland, and Yat Kitischee; these are the same three sites that contain the greatest number of cores and which had the greatest access to chert either directly or indirectly through exchange. They also have the largest excavated samples. All of these factors may have contributed to the exclusive association of hammerstones with these sites.

The results also indicate that curated tools, that is, shaped tools such as bifaces and unifaces, comprised a significant proportion of the tool assemblages during both the Archaic and post-Archaic periods. Contrary to the expectations of Parry and Kelly (1987), the ratios of curated to expedient tools actually appear to have increased during post-Archaic times. While this could be interpreted as a simple refutation of their argument and a validation of the importance of access to raw materials as a determining factor in the dependence on curated technologies, the situation is more complex, as the examination of debitage assemblages indicates.

When the waste-flake assemblages are analyzed there is a clear pattern of technological dependency on the production and maintenance of hafted bifaces during the Archaic period with both the Sullivan-Rozen and flake-size analyses producing comparable results. Post-Archaic assemblages are much more variable, and the analyses often produced conflicting results or results that suggest a mix of core-reduction and biface-reduction technologies. The variability displayed by the post-Archaic debitage assemblages is consistent with the variability exhibited in other aspects of this study, and most importantly, in acquisition patterns. I believe that the high ratios of curated to expedient tools coupled with the evidence for waste-flake assemblages that indicate mixed on-site reduction activities is the result of hafted bifaces entering many of these post-Archaic sites via exchange. Thus, on-site production of bifacial implements was not as great as during the Archaic period. Fort Center may have been an exception. The debitage analysis indicates that on-site reduction of mid-to-late-stage bifacial preforms made from Hillsborough River Quarry Cluster cherts may have occurred, and this is corroborated by the number of production rejects that are present in this assemblage. Similarly, at the Peace River sites, locally available Peace River Quarry Cluster cherts may have been used to produce some bifaces. However, despite these anomalies, core reduction appears to have been a common on-site reduction activity at most post-Archaic sites.

There also appears to be intersite differences in the use of cores during the post-Archaic. The strongest evidence for core reduction occurs at three sites: Fort Center (8GL13), Pineland (8LL33,37), and Yat Kitischee (8PI1753). Two of these sites, Fort Center and Yat Kitischee, contain evidence of a significant bipolar industry while at Pineland core technology appears to have centered on the reduction of small, amorphous cores. All of these sites can be considered to have had greater access to raw materials than any of the other post-Archaic sites except perhaps for those in the Peace River region. Yat Kitischee is located geographically near to several well-documented chert sources while the inhabitants of Pineland and Fort Center both had access to chert via trade. These sites also have some of the highest ratios of curated to expedient tools. This, in combination with the debitage analyses, underscores the importance of exchange in the import of bifacial implements at these sites. The fact that sites along the Kissimmee River and Lake Wales Ridge seem to have placed a greater emphasis on biface reduction suggests that access to lithic raw materials via exchange may have been more restricted, requiring the use of a more heavily curated technology.

In terms of time allocation, these data seem to provide conflicting results. I believe it is possible to reconcile these, however, by viewing the use of stone within the larger perspective of the total technological inventory available to the native peoples who inhabited the region. If shell and sharks' teeth are considered along with stone, then tool diversity and functional specialization would be increased appreciably for several post-Archaic assemblages. For example, Patton (n.d.1) documents 35 different tool types among the 754 marine shell artifacts at Pineland (not including net weights, dippers, cups, etc). Steinen (1982:84-87) documents at least six different types at Fort Center and Austin (1995c) identifies 24 types at Yat Kitischee. Many of these appear to have been used for specialized functions such as chiseling, chopping, boring or drilling, hammering, etc. When the entire technological inventory is considered, it appears that post-Archaic peoples practiced a strategy of resource maximization, using specialized tools to increase their rates of return over specified periods of time.

On the other hand, if time allocation is examined from the perspective of raw-material procurement and use, I believe post-Archaic peoples generally practiced a strategy of time minimization. For example, on-site production activities using siliceous stone appear to have focused on low-cost techniques such as the manufacture of flake tools and microliths using casual reduction of amorphous and bipolar cores. As discussed in Chapter 10, both of these core-reduction techniques sacrifice efficient use of raw materials for time, and thereby offset the costs of acquisition. Hafted bifaces appear to have been acquired primarily through exchange, with both the direct and indirect (opportunity) costs associated with raw-material acquisition and tool production borne by the producers rather than the consumers. Although costs would have been incurred in acquiring goods for exchange, these would have been offset by importing bifaces in finished or nearly finished condition, thereby minimizing handling costs associated with the imported goods.

This dual strategy would only have been practical where access to marine shell was high, either via direct procurement or exchange, and the costs of acquisition low or at least equal to stone. The data from the post-Archaic sites in the Kissimmee River valley appear to indicate a much higher reliance on a biface technology that is more analogous to the Archaic period, although evidence for the use of shell and sharks' teeth is present.

Turning to the Archaic period, the data indicate a reliance on the manufacture and use of bifacial implements which were heavily curated. This conforms to the expectation of resource maximization for mobile populations. However, unlike the post-Archaic debitage assemblages, the high frequencies of flake tools in Archaic assemblages do not correspond with evidence for on-site core reduction. Instead, many flake tools are simply bifacial-thinning flakes that were salvaged from available waste flakes and used in an expedient fashion when and where they were needed. The fact that the ratios of curated to expedient tools are higher for Archaic assemblages in the study area when compared to those from chert-rich areas, suggests that expedient tool use was restricted by the limited availability of suitable raw materials.

CHAPTER 12
SUMMARY AND CONCLUSIONS

Overview of the Study

In the previous chapters the various strategies that were employed by prehistoric hunter-gatherers in south-central Florida to cope with the problem of lithic-resource scarcity were examined. Chapters 1-5 presented the theoretical, environmental, geological, and cultural contexts for this research. To summarize briefly, it was proposed that the basic economic principle of supply and demand should have been a dominant factor that influenced prehistoric decisions regarding the types of organizational strategies employed in the study area. If supply decreases and demand remains constant, then the cost of acquisition will increase accordingly. Cost was related to labor effort (energy and time) and distance was used as a proxy measure of labor effort. It was further proposed that changing paleoenvironmental conditions resulted in the adoption of differential strategies of settlement mobility, and that these can be grouped roughly into two basic types. residential mobility and sedentary or semi-sedentary habitation. Although the archaeological data are limited, these settlement strategies do appear to characterize the two broad cultural-temporal subdivisions that were utilized in this study: the preceramic Archaic and post-Archaic periods, respectively.

Given these conditions and theoretical assumptions, it was expected that differences in the specific types of risk- and cost-reduction strategies related to lithic procurement would be observable in the archaeological record at both the spatial and temporal scales of analysis. In Chapter 6, a model was presented that specified the types of organizational strategies that might be expected to have been practiced by mobile and sedentary groups in a chert-poor area. Archaeological indicators of these various strategies also were specified. It was hypothesized that residentially mobile populations would have relied on direct procurement, raw-material diversification, scavenging and reuse of previously discarded lithic materials, and lithic caching as ways of guarding against the risk of procurement failure. Strategies to reduce the costs of procuring lithic resources from distant source locations should have included efforts to minimize transport costs by reducing the sizes of the items (i.e., tools and cores) transported and by practicing a high degree of lithic economizing. Scavenging behavior also was viewed as a potential cost-reduction strategy. Finally, the opportunity costs associated with the procurement and use of lithic resources was viewed in terms of the efficient allocation of time. For residentially mobile foragers, it was hypothesized that the most efficient strategy for managing time would be to manufacture tools in anticipation of future use so that rates of return during resource extraction would be maximized over a given period of time. Thus, an emphasis on the production and use of formal, curated tools was expected.

For more sedentary populations, the strategies that were expected to have been practiced to reduce the risk of procurement failure in a chert-poor area were exchange, resource diversification, scavenging and recycling, and storage or stockpiling. Strategies designed to deal with the costs associated with procurement of lithic resources should have included attempts to minimize transport costs, attempts to reduce handling (i.e., production) costs, lithic economizing, and an overall reduction in technological demand for stone through the substitution of alternative resources. Scavenging also was hypothesized to be a viable strategy for reducing production costs. Finally, because the number of time-consuming activities associated with subsistence-related activities are typically greater for sedentary populations, groups that practiced such a settlement strategy should have been time-stressed. Thus, strategies to reduce the opportunity costs related to the acquisition and use of lithic raw materials were expected to consist of a mix of resource maximization and time minimization. Resource maximization should be represented by a dependence on specialized tools designed to increase the speed with which certain tasks could be performed, while time minimization might be represented by the use of low-cost production strategies with raw materials that were expensive to acquire.

The methods used in this research were discussed in Chapter 7. The most important of these was the identification of lithic raw-material provenience. I used the quarry-cluster method devised by Sam Upchurch and his colleagues. This approach attempts to assign specific samples (artifacts) to geographic regions where chert outcrops share similar diagnostic features that can be viewed visually with the aid of a binocular microscope. Since the visual identification of lithic raw materials is controversial, and because there is a battery of instrumental techniques available for identifying the sources of siliceous lithic materials, some time was spent discussing the pros and cons of these alternative methods. A review of the available literature indicated that the success rates of studies using instrumental techniques are highly dependent on the geographic and, hence, depositional uniqueness of the source materials. When the depositional environments of the source materials are significantly different, geochemical signatures often provide highly satisfactory results. However, for most cherts that are located within a restricted geographic range, such as those in Florida, differences in the origins of deposition of the original host limestones are not great enough to produce unambiguous geochemical signatures (Upchurch et al. 1982:162-163). It is possible to assign individual samples to a parent formation with a high degree of confidence using physical properties, such as rock fabric, fossil content, and secondary inclusions. Moreover, within the limited geographic range of surface exposures of different geological formations, there often are more restricted sets of chert outcrops that share physical characteristics. This enables the assignment of archaeological specimens to one of several "quarry clusters" with an acceptable degree of confidence The availability of a large and reasonably representative type collection of geologically derived samples from all the identified quarry clusters in the state increased the confidence of the assignments.

Given the goals of this research, and the often small numbers of lithic artifacts from individual sites or components, it was desirable to examine and determine the provenience of all lithic artifacts in the chosen assemblages. Thus, a final consideration in the choice of methods for identifying chert provenience was the time and cost that are typically associated with the use of instrumental techniques, particularly when used with more than just a few artifacts. For these reasons, I concluded that the use of visually observable physical properties was the most efficient and productive method for determining raw-material provenience.

To ensure replicability by other researchers, the criteria used to assign archaeological specimens to different quarry clusters were explicitly defined. Some modifications to Upchurch et al.'s original quarry-cluster designations also were made in order to deal with the dual problem of small comparative samples from some areas and the inability to arrive at unambiguous visual criteria for distinguishing between some quarry clusters. This resulted in several quarry clusters being combined into larger clusters than had previously been proposed. Future research that emphasizes the collection of chert samples from under-represented areas may result in greater differentiation within these "megaclusters."

Since the largest class of lithic artifacts at excavated sites is debitage, and since debitage often provides clues to on-site activities related to the use of different lithic raw materials, an analysis of experimentally produced debitage assemblages resulting from the manufacture of bifacial, unifacial, and flake tools was conducted. The purpose of this analysis was to derive expectations regarding the types of assemblage structure that should result from two primary reduction strategies: patterned-tool reduction and core reduction. Statistical methods were employed to refine existing analysis techniques for use in interpreting assemblage-level data. These analysis techniques are the Sullivan-Rozen typology and Patterson's flake-size distribution. My analysis indicated that the two techniques can be used in tandem to identify different reduction strategies in archaeological assemblages. Assemblages containing a mix of tool- and core-reduction debitage can result in conflicting results; however, this problem usually can be resolved through the analysis of independent flake attributes.

Finally, in Chapters 9-11 the substantive results of my research was presented. These results confirmed that basic economic principles influenced the strategies chosen by prehistoric peoples to deal with raw-material scarcity. Furthermore, as expected, the specific strategies employed varied both spatially and temporally. When assemblages from the study area were compared with assemblages from chert-rich areas, the former typically displayed a greater emphasis on lithic-resource conservation and the use of curated technologies, regardless of the degree of settlement mobility. However, simple access to raw materials did not explain all of the organizational variability observed between culture periods and settlement types within the study area. Instead, several interdependent factors including mode of settlement (i.e., mobile or sedentary), site function and duration of occupation, and mode of resource acquisition (i.e., direct or indirect), in addition to raw-material availability appear to have contributed to intraregional variability. In the following section I summarize the specific strategies employed by Archaic and post-Archaic groups in the study area, as indicated by the results of my analyses.

Summary and Discussion of Research Results

Procurement Risk

Raw-material acquisition. While the data presented here are perhaps too patchy to arrive at a firm conclusion, the linear and hyperbolic distance-decay patterns exhibited by various raw materials in Archaic period assemblages suggest a greater reliance on direct procurement during this time. This may have been augmented with gift exchange, although this is difficult to verify with the present data. Some raw materials, notably cherts from the Hillsborough River Quarry Cluster and, to a lesser extent, the Peace River Quarry Cluster, exhibit positive linear trends with distance, i.e., their proportional representation increases. This is due in part to the nature of a closed-number system and the fact that people were moving away from sources of raw material into regions where no local materials were available to replace worn or broken tools as they were discarded. Thus, a decrease in the relative abundance of one raw material would have necessarily resulted in an increase in the relative proportion of a second raw material, even if there was no change in the absolute frequency of the second material. Since the Hillsborough and Peace River quarry clusters represent the two closest source areas for people inhabiting the study area, it is not surprising that they tend to increase proportionately at the expense of other, more distant raw materials. Consequently, the positive trends exhibited by these two materials may reflect patterns of lithic provisioning as residentially mobile groups traveled through areas containing these chert types, discarded exhausted tools made from more distant chert sources, and then moved on to chert-poor areas. This would result in a greater representation in the archaeological record of those cherts that were obtained from the last source area(s) that was visited.

In contrast, distance-decay patterns for the post-Archaic period are highly variable and this variability no doubt reflects strategies of both direct and indirect procurement, with the emphasis on one or the other dependent on the availability and access to local resources. For example, direct procurement is indicated for Peace River cherts which exhibit a gradual, negative fall-off pattern. Post-Archaic sites located in the Peace River valley consistently possess high frequencies of this material indicating greater reliance on local sources, probably as a result of a restricted territorial range. As one moves to the south, this material occurs in progressively smaller amounts in post-Archaic assemblages. For those groups who lived within a reasonable distance of the Peace River chert sources, direct acquisition may have been achieved by embedding lithic procurement in other logistical pursuits. But for groups residing in areas beyond a reasonable procurement range, Peace River cherts probably arrived via some form of exchange, possibly of the down-the-line sort. The net result of this combination of direct and indirect procurement is a gradual fall-off pattern with no clear boundary between supply zone and fall-off zone.

Despite the fact that the Peace River Quarry Cluster represented the nearest source of lithic raw materials to people inhabiting south Florida, Peace River cherts tend to have a patchy distribution in the study area, concentrating at some sites and being totally absent at others. Nor does this chert appear to have been considered anything more than a poor substitute for better-quality cherts such as those from the Hillsborough River Quarry Cluster, since the only tools made from it are small, triangular projectile points and occasional flake tools. This combination of factors -- low frequencies, patchy distribution, and limited utility -- indicates a low demand for Peace River chert and lends support to the interpretation that this material arrived at distant locales via down-the-line exchange rather than utilitarian, social, or prestige exchange.

Cherts from the Hillsborough River Quarry Cluster are the most common at all post-Archaic sites located outside of the Peace River drainage. The curvilinear fall-off pattern for this material, in combination with its wide and consistent distribution among post-Archaic sites, suggests acquisition via some form of exchange, probably utilitarian or social exchange, although direct procurement by groups inhabiting the Peace River valley may have occurred by way of logistical task groups. Curvilinear patterns also are indicated for all other raw materials. The inference of exchange for these raw materials is supported by the uniformly low flake-to-core ratios for all sites in the Kissimmee region including Fort Center, as well as at Pineland on the southwest coast. These low ratios indicate that raw materials were entering these sites in small packages, primarily as finished implements (bifaces) and small cores. Hillsborough River cherts may have been an exception, at least at Fort Center, where there is evidence for on-site reduction of preforms made from these cherts.

Fort Center's lithic assemblage is unique among those included in this research. There is evidence that some hafted bifaces at this site were acquired by exchange for use in prestige or elite contexts. Archaic stemmed projectile points, particularly those made from thermally altered silicified coral, occur with greater frequency in Mound B, a flat-topped ceremonial structure containing burials, and the associated pond, where human remains from a collapsed charnel platform were recovered. Very little debitage that can be associated with the raw materials from which these bifaces are made was found at these features, at the nearby Mound A, or at the site generally. At least two large, well-made Archaic hafted bifaces display post-production modification that rendered these implements non-functional within a utilitarian context, and one exhibits an intentional radial fracture.

Helms (1993) has argued persuasively that in traditional societies exotic items obtained from distant locales often are equated with an existence outside the normal, ordered world. She defines distance in both geographical and temporal terms, with the latter having a strong ancestral association. Furthermore, she argues that skillfully crafted goods tend to be accorded a higher value and so are preferred for special social and ceremonial functions. Burial of highly valued, ancestral objects with the dead not only validates the status and social importance of the individual, but symbolizes a reenergizing of ancestral powers (Helms 1993:142). The act of breakage serves to release the natural or ancestral potency of the item and is important as a means of returning these energies back to the ancestral source. The contexts in which Archaic hafted bifaces are found at Fort Center suggests that they were highly valued and that their "exotic" origins, both in terms of distance and age, may have contributed to their perceived value.

A second set of broad-stemmed hafted bifaces were recovered from Mound A, a structure associated with Mound B and the charnel pond, and believed to have been used by ritual or craft specialists. Many of these bifaces are made from Ocala Limestone cherts that outcrop more than 200 km from the site. Waste flakes of this material are virtually absent from the site, indicating that the bifaces were imported as finished implements. Many of these bifaces exhibit edge damage and fracture patterns indicating that they were used primarily for wood, bone, or shell-working, tasks that have been hypothesized to have been conducted by the individuals residing at the mound (Steinen 1982:77,92).

Again, Helms (1993:18-23) provides some insight into the use of artifacts obtained from distant locales in special crafting tasks. Since these artifacts are believed to possess special powers, they represent powerful energies that often are used in the transformation of nature for cultural purposes (Helms 1993:19). The use of implements that possess special powers to skillfully carve, engrave, or otherwise work wood, bone, or shell would ensure that the craft items would be successfully completed and symbolically charged.

Assuming that exotic lithic materials were conceived of in such a fashion at Fort Center, then demand for these implements would have been high, influenced in part by their use value within a symbolic or cosmological context. Lithic exchange at Fort Center can thus be viewed as supplying the inhabitants not only with materials and implements necessary for day-to-day utilitarian tasks, but with exotic items imbued with special powers and energies derived from their geographic and temporal distance.

Raw-material diversification. Archaic period assemblages exhibit a high degree of raw-material diversity indicating that a wide range of chert resources was being exploited. This, in turn, implies a large territorial range consistent with residential mobility. More importantly from an economic perspective, high resource diversity is an expected response to a situation in which high-utility resources are less abundant. This could occur when a group moves into a region where high-quality cherts are not plentiful, thereby stimulating an expansion of the lithic-resource mix. Optimization analysis of the use of thermal alteration, a technology that peaked during the middle Archaic period, suggests that its use makes economic sense only within such a context. In effect, the use of thermal alteration enabled Archaic people to broaden further their mix of lithic raw materials by allowing them to incorporate low-quality cherts into biface production.

Post-Archaic assemblages not only exhibit a less diverse range of siliceous raw materials, but there was an increased emphasis on the use of locally available resources. In the Peace River region this reduction in diversity is accompanied by an increase in the use of local Peace River cherts. At sites in the Kissimmee region, the reduction in diversity is reflected by a greater dependence on cherts derived from the Hillsborough River Quarry Cluster. Hillsborough River cherts also are common at Fort Center and Pineland, but at these sites there is evidence for the use of alternative materials such as dolomite, fossil bone, and quartz pebbles, as well as non-siliceous sandstone and limestone. All of these materials could have been acquired from nearby sources. While the increased use of local materials suggests a reduced procurement range that is consistent with limited mobility, the attempts to experiment with lower-quality siliceous materials does represent an effort to expand the resource mix. An even more important indicator of resource diversification is the increased role that marine shell and sharks' teeth played in post-Archaic technologies. This is particularly evident at coastal sites such as Pineland and Yat Kitischee, but these durable raw materials also became important substitutes for stone in the technological inventories of sites in the Kissimmee River and Lake Okeechobee regions, as evidenced by the data from Fort Center and, to a lesser extent, sites in the Kissimmee River valley and on the Lake Wales Ridge. Thus, raw-material diversification also was employed as a risk-reduction strategy by post-Archaic peoples, albeit in a different form than their Archaic period predecessors.

Scavenging, reuse, and recycling. Evidence for the scavenging, reuse, and recycling of lithic materials is present in both the Archaic and post-Archaic assemblages. Several attempts were made to quantify the degree to which this strategy occurred. Among the bifaces that could be associated firmly with cultural-temporal components, the evidence for recycling or reuse was relatively equal between Archaic and post-Archaic periods. Similarly, the ratios of broken to complete bifaces, although slightly higher among post-Archaic assemblages, were statistically similar between the two cultural-temporal periods. When compared to contemporaneous assemblages from chert-rich areas, Archaic and post-Archaic assemblages from the study area both had slightly higher ratios, but the regional differences were not statistically significant. Exceptions were the biface assemblages from Fort Center and

Pineland, both of which exhibited very low ratios of broken to complete bifaces. Yat Kitischee, which is located near lithic outcrops, exhibited a ratio of broken to complete bifaces that was comparable to those from Fort Center and Pineland. It was suggested that these low ratios may reflect higher rates of discard for hafted bifaces that retain high residual utility at permanently occupied habitation sites that operated within logistically organized settlement systems. This high discard rate could be a reflection of the attempt to reduce the risk of failure during task performance away from the habitation site where lithic raw materials and time are less likely to be available for repair and rejuvenation. These tools with high residual utility could still have functioned within the context of the habitation site, and their apparent "discard" may instead represent a form of site furniture that became permanently associated with the residential location. In effect, these slightly worn tools were stored or cached in anticipation of future use at intrasite locations where the risk of failure was not as great.

Another important factor to consider with regard to the larger numbers of complete bifaces is that all three of these sites had access to alternative sources of raw materials, either directly or indirectly. This might have enabled the sites' inhabitants to use marine shell and sharks' teeth to perform some tasks that might normally have been conducted using stone tools. Thus, the use of stone at these sites may have been restricted to tasks for which they were best suited and so resulted in less tool breakage.

A third factor that may have influenced the high rate of discard for complete bifaces is the use of "exotic" bifaces in ceremonial or ritual contexts. For example, the interment of complete bifaces as grave goods would serve to inflate their representation relative to broken bifaces. This certainly seems to have been a factor in the low ratio of broken to complete bifaces at Fort Center.

Post-Archaic assemblages from habitation sites along the Kissimmee River exhibit high ratios of broken to complete bifaces. Archaeological excavations at these sites were limited to isolated test units, while at Fort Center, Pineland, and Yat Kitischee, the excavation strategies emphasized large-scale block excavations and/or the large areal distribution of test units. Thus, it is possible that complete bifaces were discarded at locations within the Kissimmee River sites that were not sampled during testing. A second possibility is that bifaces were transported to and discarded at off-site locations. If true, this would suggest a different type of discard pattern. A third possibility, and the one I think is more plausible, is that access to durable raw materials, including both siliceous stone and marine resources, was more restricted at the Kissimmee River sites. Consequently, there would have been a greater need for using bifacial tools past the point of exhaustion as well as a greater need to salvage usable broken pieces.

The best indicator of scavenging behavior appears to be the ratio of small to large biface fragments. These ratios were approximately twice as great in assemblages from the study area when compared to contemporaneous assemblages from chert-rich areas. This comparison was hampered, however, by the small sample of sites from chert-rich areas that had size data recorded for broken bifaces. Nonetheless, it appears that these ratios reflect more intensive use of larger biface fragments as possible "cores" or "blanks" that could be recycled with minimal modification and reintegrated into the active technological system.

Storage. While the evidence for storage and caching behavior is not overwhelming, it is present at three sites: a "cache" of chert cobbles at Fort Center's Mound A, a concentration of rod-like pieces of chert and the microliths made from them at Yat Kitischee, and three complete hafted bifaces and associated production debitage at the Driggers #2 site. The first two are post-Archaic habitation sites and the last is an Archaic period campsite. Additional occurrences of lithic caches were cited from the archaeological literature, many of which are located in chert-rich areas. The presence of caches in both chert-rich and chert-poor areas seems to argue against the hypothesis that caching or stockpiling of lithic raw materials is solely a response to the problem of an anticipated shortage. Instead, it appears likely that caching also was a means of dealing with the opportunity costs that develop when mutually exclusive activities cannot be performed simultaneously. When viewed in this fashion, the concept of storage and caching can be extended to discarded lithic items that are available for future scavenging, reuse, and recycling, such as flakes, exhausted cores, or broken tools. The presence of caches, as well as the salvaging of discarded items, also implies regular and anticipated reuse of specific locations on the landscape.

The association of the cache of chert cobbles with Mound A at Fort Center is significant since this is a feature that has been hypothesized to have been a center of craft specialization that may have been related to the ritual activities conducted at Mound B and the charnel pond. The restricted distribution within Fort Center of the cobbles, as well as the tools and waste products resulting from their reduction, suggests that the individuals who resided at Mound A controlled access to and use of this material, and perhaps other lithic raw materials as well.

Procurement Costs

Minimization of transport costs. Analysis of the sizes of cores and the amount of cortex material in debitage assemblages both indicate that Archaic and post-Archaic people attempted to minimize the cost of transporting lithic materials from distant locations by reducing the mass of material that had to be carried. However, the underlying reasons for this differed as a consequence of the types of procurement strategies that were employed. For Archaic populations practicing primarily a direct acquisition strategy, the elimination of unwanted waste materials was a direct response to the costs of transport and so it occurred quite rapidly after the raw material was acquired from the source. Distance-decay patterns for Archaic assemblages indicate dramatic fall-offs in both core size and amount of cortex material within 5-10 km of chert sources. In contrast, post-Archaic populations practiced a more diverse array of procurement strategies and consequently distance-decay patterns indicate more variability in the fall-off patterns for core size and cortex. For example, core size tends to exhibit a slight increase with distance, influenced perhaps by the slightly larger core sizes at Fort Center and Pineland. The amount of cortex material also exhibits greater variability with the same two sites, Fort

Center and Pineland, exhibiting high ratios of cortex to noncortex flakes The fall-off pattern for cortex material is much more gradual when compared to the Archaic data, with the fall-off boundary occurring at a distance of about 25 km from source areas. Again, this is interpreted as a reflection of the variability in procurement strategies during the post-Archaic, with both direct acquisition of local resources and indirect acquisition of distant resources contributing to the pattern.

In terms of tool size, both Archaic and post-Archaic hafted bifaces tend to be smaller than their counterparts in chert-rich areas. However, the factors involved are more complex than simple transport considerations. For example, several lines of evidence indicate that Archaic groups were highly dependent on a curated, biface technology and that bifaces of variable sizes and stages of reduction were being transported into the study area. While flake-to-core ratios are much lower than they are at assemblages from sites located in chert-rich areas, indicating that most early-stage reduction was carried out near a chert source, they do tend to be variable between sites and composite assemblages from the study area. This variability suggests that both preforms and finished implements were being transported and reduced at different sites. While the sizes of hafted bifaces tend on average to be smaller than those in chert-rich areas, the range of variability in individual tool sizes is relatively large. When the size indices of individual Archaic projectile points are plotted versus distance to the nearest chert source, the result is a gradually decreasing linear pattern with a rather large spread of data points around the regression line. This distance-decay relationship matches the pattern predicted for mobile groups practicing a planned staging of reduction and rejuvenation of large bifaces to ensure that enough raw material remains for a return trip to a source location. Such a strategy would result in bifaces of variable sizes being discarded at variable distances from the source location as some tools become exhausted and are replaced by larger, unused implements. While these results do not completely contradict the hypothesis that smaller tools should be transported by mobile groups, the data on tool rejuvenation discussed below suggests that some of the variability in tool size is due to distal blade resharpening.

Thus, the data tend to provide stronger support for Morrow's (1996) formal analysis which indicates that the optimal solution to the problem of lithic provisioning for people practicing a mobile lifestyle is to transport large tools so as to maximize use-lives and residual utility.

While the average sizes of many post-Archaic hafted-biface types are smaller than similar types recovered in assemblages from chert-rich areas, the distance-decay patterns are more variable than those exhibited by the Archaic types. Several post-Archaic hafted-biface types exhibit increases in size with distance suggesting that they arrived at these distant locations via exchange, possibly of the prestige variety. Other hafted-biface types exhibit a gradual decline in size with distance suggesting down-the-line exchange. Significantly, many of the largest examples of Archaic and post-Archaic hafted-biface types occur at Fort Center, particularly at the mound-pond complex. This further reinforces the interpretation of prestige exchange for some lithic materials entering this site.

Lithic economizing. Both Archaic and post-Archaic groups attempted to conserve lithic raw material through tool maintenance and edge rejuvenation strategies, although the degree to which these conservation measures were practiced differed temporally. For example, Archaic hafted bifaces exhibit a high degree of both lateral and distal resharpening while distal resharpening appears to have been more common among post-Archaic hafted bifaces. This difference could be interpreted as a reflection of more specialized use of bifaces during the post-Archaic, but this is not supported by the use-wear data which indicate that bifaces were used for a wide variety of tasks during both cultural-temporal periods. A comparison of reduction indices with the size indices for individual specimens indicates that the smaller sizes of Archaic bifaces is partly the result of distal blade reduction; however, many Archaic bifaces also appear to have been manufactured in smaller sizes. The greatest variability in tool size and reduction intensity is exhibited by specimens from chert-rich areas. This is not surprising since this would be the area where the discard of exhausted tools would be expected as groups reprovisioned their tool kits.

Conservation of raw materials also is indicated by the numbers of retouched tools in the non-biface assemblages. The ratios of retouched to unretouched tools in Archaic and post-Archaic assemblages are significantly higher than they are in contemporaneous assemblages from sites in chert-rich areas. The number of functional units on flake tools and microliths also is high while the ratios of flakes to flake tools is lower when compared to assemblages from chert-rich areas. All of these indicate greater attempts to utilize available raw materials more intensively within the study area.

On the other hand, intraregional variation is apparent with regard to the use of conservation practices. For example, the ratios of flakes to flake tools is consistently lower in all post-Archaic assemblages when compared to Archaic assemblages, indicating more intensive use of available materials for tools. An exception is the Peace River assemblages which exhibit similar ratios for assemblages from both cultural periods. Flake tools and microliths from Fort Center and Pineland do not appear to have been used as intensively as those from contemporaneous sites in the Kissimmee and Peace River regions, as indicated by the fewer numbers of functional units employed on flake tools. The fact that these two sites share this last pattern with Yat Kitischee, a coastal site in a chert-rich area, suggests that it may be due to the availability of shell and sharks' teeth which could be substituted for stone to conduct some tasks.

Minimization of production costs. The debitage analysis indicates that Archaic period groups relied more heavily on a curated biface technology than did post-Archaic groups, at least in terms of production. Although cores were transported and reduced, as indicated by a few small, exhausted bifacial cores and by the debitage assemblages of some raw materials that appear to have resulted primarily from small-core reduction, the dominant reduction activity at Archaic sites appears to have been biface production and rejuvenation

In contrast, on-site reduction activities during the post-Archaic appears to have focused on small, amorphous-core reduction and, to a lesser extent, bipolar-core reduction. This is indicated by the waste-flake assemblages as well as the predominance of amorphous and bipolar cores in post-Archaic assemblages. Many, but not all, bifaces appear to have entered post-Archaic sites in the study area via exchange.

The use of low-cost core-reduction strategies was hypothesized as an effective way to deal with high procurement costs since the labor effort involved in production of expedient tools is typically much less than for curated tools. However, amorphous- and bipolar-core reduction strategies are not particularly efficient in terms of raw-material conservation. Bipolar-core reduction, in particular, produces a comparatively large amount of unusable waste. On the other hand, the use of an anvil helps to prolong the use-lives of small amorphous cores, and so enables the flintknapper to maximize the number of flakes that can be extracted from a given piece of raw material. Thus, it is perhaps not surprising that evidence for anvil use is fairly common in both the Archaic and post-Archaic assemblages, while the use of what appears to be a true bipolar technique is comparatively rare and limited to only two sites: Fort Center, where small cobbles were available, and Yat Kitischee, where small chert rods where used to manufacture microliths. Thus, core-reduction strategies at these post-Archaic sites served the dual purpose of conserving time as well as raw materials.

Another possible reason for the emphasis on core-reduction technologies in post-Archaic assemblages is the manufacture of flake tools that could be used in tasks such as cutting, scraping, engraving, and perforating, and so conserve more expensive hafted bifaces (Johnson 1986). Again, we might expect this strategy to be practiced most intensively at sites where access to raw materials for use in core reduction was greatest. Core-reduction appears to have been most common at Fort Center, Pineland, and Yat Kitischee as indicated by the debitage analysis as well as by the absolute numbers of cores. The post-Archaic assemblages in the Kissimmee region exhibit much less reliance on core reduction.

Reduction in lithic demand. A reduction in lithic demand during the post-Archaic period is indicated by both a quantitative decline in the amount of lithic artifacts and by the increased importance of alternative raw materials, particularly marine shell and sharks' teeth. The acquisition costs associated with siliceous stone when compared to marine shell appear to have been a significant factor in these shifts in raw-material preferences.

Intensification of exchange relations during the post-Archaic may also have been a factor in the use of local versus exotic raw materials, at least on the southwest coast. Although the data are limited, the use of siliceous raw materials by coastal Archaic populations appears to have been extremely limited, even less than during the post-Archaic. In fact, when compared to the post-Archaic Pineland assemblage, there is a quantitative increase in the use of lithics at coastal sites during the post-Archaic. It was postulated that this relative increase may have been the result of the import of lithic materials via trade at Pineland.

Opportunity Costs

The results of the analyses designed to evaluate whether strategies of resource maximization or time minimization were practiced produced results that contradicted many of the expectations outlined in Chapter 6. For example, neither the Archaic nor the post-Archaic assemblages exhibited high tool diversity, nor did they appear to be particularly specialized. Only three tool classes are associated with restricted numbers of tasks at both the specimen and class levels: microliths, unifaces, and hammerstones. Microliths and hammerstones are common in post-Archaic assemblages while unifaces are more common in Archaic assemblages. The results also indicate that curated tools, i.e., shaped tools such as bifaces and unifaces, comprised significant proportions of the tool assemblages during both the Archaic and post-Archaic periods. In fact, the dependence on curated tools (i.e., bifaces) actually appears to have increased during post-Archaic times.

In evaluating these results it was suggested that the degree of tool diversity and, by extension, the dependence on functionally specialized tools, may have been underrepresented in these assemblages by focusing only on stone tools. In order to arrive at a valid characterization of tool diversity, it is necessary to include other tools made from marine shell and sharks' teeth. When this is accomplished, tool diversity and functional specialization is clearly higher in those post-Archaic assemblages for which such data exist. Although it was difficult to effect a similar comparison for interior Archaic sites because of the problem of preservation, a similar inference can be made for documented Archaic sites located on the southwest coast where marine shell and sharks' teeth were used for a wide range of tool types, and for which there is evidence for permanent, year-round habitation (e.g., Russo 1991).

The debitage analyses indicated a clear pattern of technological dependency on the production and maintenance of hafted bifaces during the Archaic period with both the Sullivan-Rozen and flake-size analyses producing comparable results. However, post-Archaic debitage assemblages were found to be much more variable in composition. The two analyses often produced conflicting results or produced results that suggested a mix of core-reduction and biface-reduction activities. I suggested that the high ratios of curated to expedient tools in combination with debitage assemblages that appear to have resulted from a mix of biface- and core-reduction activities can be reconciled by considering that hafted bifaces appear to have entered many of these post-Archaic sites by way of exchange. Consequently, on-site production of bifacial implements was not as great as during the Archaic period and so core reduction is better represented in the debitage assemblages.

There were exceptions to this generalization, however. Fort Center, for example, while exhibiting abundant evidence for core reduction, also contains evidence for the on-site reduction of mid-to-late-stage preforms made from Hillsborough River Quarry Cluster cherts. Similarly, sites in the Kissimmee region, particularly those located in the Kissimmee River valley, appear to have depended more heavily on a biface technology, although some core reduction did take place.

Core reduction was best represented at Fort Center, Pineland, and Yat Kitischee, sites where access to raw materials was perhaps greater than at other post-Archaic sites in the region, either because of direct access (Yat Kitischee) or indirect access (Fort Center and Pineland). Importantly, the debitage analyses indicated that there were differences in the ways in which different raw materials were used during both the Archaic and post-Archaic periods. While this was not investigated fully, it seems reasonable to assume that acquisition costs and raw-material quality were factors that influenced how specific raw materials were used. For example, at Fort Center, core reduction is most strongly indicated for the chert cobbles and Peace River Quarry Cluster cherts. The former occurs as small cobbles that often have internal voids and flaws. The sizes of these cobbles limited their use for anything other than flake tools and microliths. Peace River cherts tend to be brittle and full of phosphate, quartz sand, and earthy inclusions that inhibit their use for large, labor-intensive tools such as hafted bifaces. This material was used primarily for small triangular projectile points and flake tools. A similar situation is evident at Pineland where Type 4 chert from the Hillsborough River Quarry Cluster appears to have been used primarily in core-reduction. This raw material is relatively coarse grained and often contains voids and fossil casts that increase the chance of critical fracture.

In comparison, the high frequencies of flake tools in Archaic assemblages do not correspond with evidence for intensive on-site core reduction. Instead, most of these tools are bifacial-thinning flakes that were salvaged from available waste flakes and used in an expedient fashion.

In summary, Archaic assemblages in the study area are characterized by low tool diversity with flake tools and bifaces the dominant tool classes, low functional diversity, and a technological dependence on biface manufacture. Post-Archaic assemblages also exhibit low lithic tool diversity and low functional diversity, but when tools made from shell and sharks' teeth are included, tool diversity and functional specialization increase substantially. Many, but not all, post-Archaic sites exhibit evidence for a technological dependence on core reduction. The high ratios of curated to expedient tools is believed to be primarily the result of the import of hafted bifaces via exchange, although direct procurement by logistical task groups cannot be ruled out for groups inhabiting the Lake Wales Ridge or the Kissimmee River valley. The relationship between the sites located in these two areas is not clear. Very preliminary data from the Blueberry site (8HG678) suggest that this site may have been occupied seasonally, perhaps during the fall and winter months. Whether there was a seasonal movement of Belle Glade groups between the river valley and the ridge has not been determined and is an area of research that must be addressed in the future. If such seasonal movement did occur, then groups inhabiting the Lake Wales Ridge during the fall and winter months could have sent logistical tasks groups to the Peace River region to procure chert there, trade with local groups inhabiting the region, or even exploit directly the eastern extent of the Hillsborough River Quarry Cluster.

The reliance on the manufacture and use of bifacial implements that were heavily curated during the Archaic period conforms to the expectation of resource maximization for mobile populations. The use of thermal alteration also is a labor-intensive technology that was associated with the use of hafted bifaces within a mobile settlement strategy. The increase in handling time (i.e., processing time) that is indicated by the dependence on a biface technology would seem to be at odds with optimal-foraging theory which predicts that when distances from the central place to the resource patch is great, package size is more important than handling time. However, if package size is interpreted in terms of the amount of usable stone that is acquired and transported from the resource patch, then it is possible to explain the investment in handling time as a means of maximizing "package size," or the amount of usable stone that can be transported. In effect, the additional handling time required to work the raw material into finished implements or preforms represents a balance between maximizing net return rates and minimizing transport costs (cf. Metcalfe and Barlow 1992).

Post-Archaic populations appear to have practiced a more complex strategy for managing time. Resource maximization is indicated when the entire technological inventory, that is, stone, shell, and sharks' teeth, is considered, since it is only then that the full range of specialized tools in these assemblages becomes apparent. These specialized tools would have been used to perform specific tasks more efficiently. On the other hand, if time allocation is examined from the perspective of raw-material procurement and use, then post-Archaic peoples generally practiced a strategy of time minimization, with on-site production activities using expensive siliceous stone focused on low-cost techniques such as the manufacture of flake tools and microliths using casual reduction of amorphous and bipolar cores. Both of these core-reduction techniques sacrifice efficient use of raw materials for time, and thereby offset the costs of acquisition by reducing handling time. Moreover, by acquiring hafted bifaces through various types of exchange, it was possible to deflect the direct and indirect (opportunity) costs associated with raw-material acquisition and tool production to the producers. The costs associated with acquiring goods for use in exchange were similarly offset by importing these bifaces in finished or nearly finished condition, thereby minimizing handling costs associated with the imported goods.

This strategy could be extended to marine shell as well. For those post-Archaic groups that inhabited the coast, the acquisition of marine shell and sharks' teeth would have entailed no or very little opportunity costs because it was naturally embedded in subsistence pursuits. Thus, the expenditure of additional labor time to manufacture specialized, curated tools from these materials was offset by the low cost of acquisition. For interior groups, acquiring these materials in the form of finished tools would have reduced handling costs and offset the high costs of acquisition. While this study did not address the technology of shell-tool production, it would be worthwhile to examine the shell artifacts from interior sites to determine if on-site production did occur at these sites, or if the tools arrived as finished products The use of shell as a raw material also conforms to Hames's (1992) expectations regarding the use of technologies in a time-limited context since the time spent in resource acquisition is less than for stone with no substantial increase in time spent in production. In many ways, shell is the perfect time-minimizing raw material because acquisition exacts no opportunity cost in terms of time spent away from subsistence pursuits

The use of time minimizing techniques within the lithic industry would only have been practical where access to marine shell was high, either by direct procurement or exchange. The debitage data from the post-Archaic sites in the Kissimmee River valley appear to indicate a much higher reliance on a biface technology that is more analogous to the Archaic period. I have suggested that this is a result of these outlying settlements having less access to all raw materials through exchange than larger settlements such as Fort Center. Additional research needs to be done to verify this hypothesis.

Economics and the Evolutionary Process

In this section I discuss the implications of the research presented in this dissertation for understanding the evolution of prehistoric societies in south Florida. Of particular interest is the effect that the establishment of exchange systems had on the emergence of social inequalities within late prehistoric Belle Glade society. While lithic raw materials formed only one component of the technological realm of native economies in south Florida, I believe that it was an important component since it, along with other durable materials such as marine shell and sharks' teeth, served to support the economic infrastructure of Belle Glade society. Moreover, the establishment of exchange systems that functioned in part to move these raw materials from their source locations to the interior, provided the opportunity for manipulation and control of both surplus goods and prestige items by individuals, leading ultimately to the emergence of social stratification and political complexity

The Subsistence and Political Economies

Johnson and Earle (1987:11-15) have subdivided traditional economic systems into two parts: the subsistence economy and the political economy. Both contribute to the evolutionary development of societies, albeit in different ways and according to different sets of operational dynamics. To the extent that lithic raw materials functioned primarily in the technological realm, they can be said to have formed part of the prehistoric subsistence economy, which is organized to meet the basic needs of the household. But lithic raw materials also functioned within the context of the political economy of prehistoric south-central Florida. This economic sector typically involves the exchange of goods and services, and at its most evolved, functions to generate surplus that is used to finance the ruling elite.

Because the subsistence economy is usually organized at the level of individual households, it tends to remain relatively stable unless there are changes in the environment, in the technology used to exploit that environment, or in population density (Johnson and Earle 1987:11-13). Within the study area, temporal changes in organizational strategies within the technological realm do seem to be correlated with temporal changes in settlement patterns. These, in turn, appear to have been part of a general adaptive response to the emergence of a more modern environment in south Florida, and specifically the development of productive marsh-riverine habitats containing abundant, dependable food resources that were relatively inexpensive to exploit in terms of time and energy.

The shift from a mobile to a more sedentary lifestyle required different strategies for acquiring durable raw materials to support the subsistence economy. The result was the emergence, or perhaps elaboration, of interregional exchange relations. From an evolutionary perspective, the specific organizational structures of lithic assemblages in south Florida are seen as elements of a larger adaptation to changing environmental conditions. By reducing the direct and indirect (opportunity) costs of procuring lithic raw materials, prehistoric native peoples were able to devote more time to activities related to energy-capture, reproduction, and social elaboration. The development of complex networks of interregional exchange is perhaps the most important difference between Archaic and post-Archaic economic systems in south Florida since it provided the necessary ingredients for the emergence of a political economy that was controlled and manipulated by social elites, i.e., individuals who acted in their own self-interest to enhance their status and power within the community, as well as those of their related kin. As Maschner and Patton (1996) have pointed out, an important feature of lineage-based societies is that status is inherited, thus making it subject to selection. Status and rank were not simply of economic benefit to individuals; they also provided access to other high status individuals as spouses (Maschner and Patton 1996:97).

Within this framework, the importance of a dependence on non-local materials should not be underestimated. Most stone tools, for example, were manufactured with the intent to use them for the production of other procurement tools (Purdy and Beach 1980). Stone was used to make wooden digging sticks, wood or bone foreshafts, wooden spear, dart or arrow shafts, antler socket hafts, and bone pins, awls, or projectile points. Stone also was used for drilling, perforating, and engraving wood, bone, antler, or shell as well as for cutting and processing wood for structures, drying racks, and dugout canoes. Without suitable stone, the only other raw materials that could have been used for these tasks would have been marine shell and sharks' teeth. In addition, durable raw materials also were integral to the maintenance of Belle Glade religious ritual and ideology. The intricately carved wooden effigies found at Fort Center (Sears 1982) and the Belle Glade site (Willey 1949b) could only have been produced using stone, shell, or sharks' teeth on wood. Several apparently non-functional hafted bifaces also were found in Fort Center's charnel pond and in the ceremonial Mound B. Thus, it appears that the iconographic and ceremonial elements of the Belle Glade ideological system also rested on a technological base dependent on the acquisition of raw materials that were not indigenous to the area.

The restricted distribution of exotic goods, including certain lithic artifacts, to the mound-pond complex at Fort Center suggests that these items functioned as prestige goods. Exchange in prestige goods appears to have occurred during two episodes -- one during Sears's Period II, and the other following historic contact. The marked decrease during the intervening Period III of the types of exotic materials associated with prestige exchange, as well as the apparent abandonment of ceremonial activities at Fort Center documented by Sears, at present remains an enigma. However, if the prestige items associated with the mound-pond complex do reflect an incipient political economy, then we should expect that this economy would have been relatively unstable and subject to both internal and external disruptions (Johnson and Earle 1987:13). This inherent instability tends to result in cyclical patterns whereby the political economy grows to its maximum limit, collapses, and then begins to expand again (cf. Cobb 1991). Widmer (1988:278) has implied that the inability to grow maize at an intensive level may have been a factor in the decline of Fort Center; however, the degree to which maize was grown and contributed to Fort Center's economy remains unclear (e.g., Johnson 1990, 1991; Milanicb 1987, 1994:290-291). Whatever the proximate cause, a second cycle of prestige exchange appears to have occurred after A.D. 1500 and is associated with a chance historical event -- the coming of the Spanish. The fortuitous influx of gold, silver, copper, lead, and iron salvaged from Spanish shipwrecks represented a new form of wealth that may have enabled Calusa leaders inhabiting the southwest coast to exercise their power and authority over outlying communities in ways that were not formerly available to them (Marquardt 1986:67), resulting in the political dominance that the Calusa apparently demonstrated at the time of Spanish contact.

A Model for the Role of Exchange in the Emergence of Social Inequality

The importance of exchange in the solidification of relations and the creation of alliances bas been acknowledged and emphasized by many anthropologists and archaeologists studying the problem of complexity (e.g. Brose 1979; Braun 1986; Braun and Plog 1982; Earle 1987; Fried 1967; Kipp and Schortman 1989; Rathje 1971; Webb 1974). A review of these and other similar studies indicates that three features characteristic of exchange relations are of particular importance to the archaeological study of complexity. First, the term exchange implies that there is a reciprocal flow of items or behavior between two or more parties. Also, the advantageous position of individuals or groups in a network of exchange relations often can be used to manipulate the system in an effort to attain and wield power. Finally, exchange systems, like the social systems in which they operate, are dynamic and can change in form and function through time. This last feature is an often overlooked fact, and as a consequence the full-scale presence of complex exchange systems is often assumed without consideration of the processes that resulted in their origin. In the following discussion, I emphasize the temporal developments that may have resulted in the development of large-scale exchange systems that were operative during the post-Archaic period in south Florida.

These exchange systems may have had their origins during the earlier, Archaic period. A settlement strategy that emphasizes high residential mobility implies a band level of social organization with kin-based or clan-based integrative social mechanisms in operation (e.g., exogamy, patrilocal residency, patrilineal descent, etc.). As Bender (1978) points out, this type of social organization sets the stage for alliance building through the reciprocal distribution of goods between clans and along lineage lines. Since the archaeological evidence suggests that at least some of the pioneer populations that migrated into the interior of south-central Florida may have come from what is today the Hillsborough County area (Austin 1996b), it would be expected that social alliances with clan members in these areas would continue to be maintained. The appearance in south Florida Archaic assemblages of implements made from cherts derived from distant locations such as the Brooksville, Lower Suwannee/Lake Panasoffkee, and Ocala quarry clusters, may reflect the existence of informal exchange between clan members which may have occurred at seasonal gatherings.

As social groups fissioned and migrated to new areas, it would have been advantageous to maintain redistributive exchange between clans and lineages. This would have provided people living in different areas with a more diversified subsistence base which would have helped guard against food shortages as well as maintaining access to needed raw materials (Brose 1979; Johnson and Earle 1987:16). This may have been what happened in south Florida as changing environmental conditions during the middle and late Archaic periods enabled the exploitation of previously unfavorable environments (see Chapters 3 and 5). The subsequent shift to a more sedentary lifestyle during the post-Archaic period, coupled with reduced access to chert sources as people settled in the Kissimmee River valley and around Lake Okeechobee, created the need to develop alternative ways of obtaining stone for tool making. The preexisting networks of social relations based on clans or lineages would have provided a foundation for the development of a system of economic exchange which would have effectively moved the resource to the consumers.

These existing exchange relations could also have been responsible for supplying the interior with shell and sharks' teeth. The centralized location of Belle Glade groups put them in an enviable position with which to expand these networks to include other parts of the state. In addition to the Lake Wales Ridge, which provided an overland route to chert resources, the Kissimmee River led directly to the lower St. Johns region while the Peace and Caloosahatchee Rivers led to the southwest coast. The east coast could have been accessed by various small streams, rivers, and slough systems connecting with the east side of Lake Okeechobee. Canal construction during the late prehistoric period may have followed these natural canoe trails, facilitating the movement of trade goods between the southwest coast and the interior (Luer 1989).

The dependence on exchange to satisfy raw-material needs is important because of the reciprocal obligations and dependency relations that are engendered as a result. Not only do these serve to reduce intergroup competition and increase differential survivability, particularly in areas where there are geographic or temporal disjunctions in the distribution of critical resources, but they also provide the opportunity for individuals to exercise control over the acquisition and redistribution of exchanged goods. This creates the conditions (e.g., enhanced prestige, authority, and political power) that are conducive to the emergence of social inequality (Bender 1978, Hayden 1990). The need to acquire naturally occurring raw materials can thus be viewed as an important contributing factor to the development of exchange systems in the Kissimmee River valley and Lake Okeechobee basin. These exchange systems served as a means of acquiring the raw materials necessary to support the subsistence economy while also providing individuals with the opportunity to accumulate and control the distribution of a variety of surplus goods and prestige items, and so provided the impetus for an emergent political economy.

The best evidence for this emergent political economy based on exchange is associated with Sears's Period II at Fort Center, ca. A.D. 200-800. The exotic cherts, galena, mica, metamorphic stone, and ceramics at Fort Center, as well as at other sites such as Belle Glade (Willey 1949b) and the Royce Mound (Austin 1993), indicate that a variety of exotic materials were being transported to the region from quite distant sources. The occurrence of these exotic artifacts in burial contexts, the evidence of mortuary ceremonialism, and large earthwork construction indicate a more complex social organization and social differentiation based on status. The Archaic hafted bifaces at Mound B and the charnel pond at Fort Center may have been symbols of this elevated status within Belle Glade society.

Significantly, there is no evidence of political centralization in the region during this time. Fort Center, as important as it was, was not unique. The many similar earthworks sites that are dispersed throughout the Lake Okeechobee basin and Kissimmee River valley, as well as the middens and smaller earthworks that occur along the various drainages and on the Lake Wales Ridge, are suggestive of autonomous, small-to-medium-sized social units perhaps occupied by lineages, with lineage lands identified by burial mounds (e.g., Pardoe 1988). Belle Glade society may have been organized at what has been termed a "big man" level; that is, an essentially egalitarian society with a few individuals in each community who enhanced their power and prestige by either dealing in exotic goods, acting in the role of religious specialist, or both. The fact that exchange necessary to support the economic infrastructure was dependent on materials flowing from a number of different geographic areas would have reinforced the autonomous nature of the local villages since each subregion could acquire access to materials needed elsewhere within the Belle Glade sphere. For example, chert from the north could have been exchanged for shell from the southeast or sharks' teeth from the southwest. The adaptive benefits of a system of external exchange and internal redistribution between communities would have provided the opportunity for increased status of those responsible for acquiring and redistributing the goods. At the same time, a diversified system of external exchange, the dispersed nature of the local subsistence resources, and low population density in the interior would have made centralization of authority neither necessary nor efficient.

While it is unlikely that ceremonial centers like Fort Center represent early chiefdoms, control of trade networks by local "big men" no doubt enabled them to increase their status and power through the accumulation and redistribution of exotic prestige items. At the same time, they could have continued to obtain and redistribute needed raw materials. As Webb (1974:367) has pointed out the two systems often reinforce one another. The economic system ensured that there were exotic items that could be used in ceremonial activities, while the ceremonial activities ensured that the economic system would continue to exist by maintaining a demand for products that stimulated utilitarian production. This is hinted at archaeologically by the conspicuous consumption of chert in ritual activities at Fort Center and other sites in south Florida, particularly the ritual breaking and interment of exotic bifaces with the dead.

Control of these materials at the intrasite level is indicated at Fort Center by the restricted distribution of certain exotic items such as Archaic hafted bifaces, thermally altered silicified coral, broad-stemmed bifaces made from exotic cherts, and the chert cobbles, all of which were concentrated in the mound-pond complex. Furthermore, Steinen (1982:Tables 6.1-6.4) indicates that marine shell and sharks' teeth also were especially abundant at the mound-pond complex relative to their occurrence in outlying living areas, as were other exotic items. Finally, the apparent concentration of certain lithic raw materials, and the implements made from them, at sites like Fort Center, in conjunction with their relative absence at smaller habitation sites along the Kissimmee River and on the Lake Wales Ridge, is suggestive of localized control and perhaps redistribution at the intraregional scale.

From these patterns it is possible to see the beginnings of a political economy that differed from the basic subsistence economy in terms of its goals and operational dynamics. The resulting social stratification that developed as a result of individuals manipulating this political economy eventually culminated in the chiefdoms that were encountered by the Spanish in the sixteenth century.

Conclusions

In terms of the economics of lithic resource use, there are four basic conclusions that can be drawn from this research. First, the basic economic principle of supply and demand does appear to have been operative within the study area and did influence choices of specific strategies for coping with the costs associated with acquiring lithic resources from distant locations. Comparison of assemblage data from the study area with similar data from chert-rich areas indicates that both Archaic and post-Archaic populations practiced cost- and risk-reduction strategies to a greater degree than their contemporaries farther north. If the assumptions regarding differential settlement mobility between these two cultural-temporal periods are correct, then access to raw materials rather than degree of settlement mobility appears to have been more important in determining the organizational structure of lithic assemblages in the study area.

The second conclusion is that specific cost-reduction strategies within the study area varied temporally and, to a certain extent, spatially. The factor that appears to have been most important in understanding why certain strategies were chosen at this intraregional scale is settlement mobility This, in turn, is related to two closely interdependent factors: 1) the specific type(s) of procurement strategies that were utilized, i.e , direct or indirect, and 2) access to raw materials, which includes both siliceous stone and alternative, substitutable raw materials such as marine shell and sharks' teeth. Where raw materials were unavailable, or more precisely, where the costs associated with acquiring raw materials directly were greater than the benefits, an indirect procurement strategy was employed. This appears to have been the case only with sedentary populations located at distances too great to allow for logistical procurement. The sites where this strategy are most strongly indicated are Fort Center and Pineland. Post-Archaic sites in the Kissimmee region (i.e., in the Kissimmee River valley and along the Lake Wales Ridge) probably also acquired lithic raw materials via exchange, however, the archaeological indicators are not as strong. Fort Center appears to have been an important trade destination for a variety of commodities and may have served as a distribution center for lithics. Smaller habitation sites, such as those in the river valley, may not have had direct access to large-volume trade goods and may have had to be content with materials that made their way to outlying hamlets from distribution centers such as Fort Center. Gift exchange is another likely source of materials for these sites. Finally, seasonal movement into areas of greater resource abundance cannot be ruled out for these groups.

The third conclusion is that post-Archaic assemblages tend to exhibit much greater variability in terms of the various analysis results than did Archaic period assemblages. In Chapter 6 it was noted that the model relating organizational responses to various cost-reduction problems suggested that sedentary populations would practice more varied kinds of organizational strategies. This appears to be born out by the data presented here. It is likely that this is due to the greater variability in site types that are present within a settlement system that is organized logistically. One pattern that became obvious during this research is the uniqueness of Fort Center, Pineland, and Yat Kitischee when compared with other post-Archaic assemblages. These three sites consistently shared similar traits that served to separate them from other post-Archaic sites despite the fact that they occupy three different environmental locales. This may be due to the degree of variability inherent in their technological systems brought about by having greater access to more varied raw materials either directly or through exchange.

Finally, the results indicate that curated and expedient technologies are not necessarily independent strategies, but instead are interdependent, with both strategies being used by many social groups (cf. Bamforth 1986; Thacker 1996). The degree to which one or the other organizational strategy is emphasized is based on 1) environmental context, which includes the availability of durable raw materials, and 2) planning, which includes the efficient use of time (cf. Nelson 1991:58; Odell 1996).

In general, the results of the present research are consistent with those of other archaeologists and anthropologists who have examined different aspects of traditional economic systems in that minimization of the effort necessary to meet basic needs appears to have been the underlying economic goal (cf., Christensen 1980; Earle 1980; Jochim 1976, 1983; Johnson and Earle 1987). Furthermore, the use of varying mixes of cost- and/or risk-reduction strategies that were employed by different native groups in order to deal with the economic need for durable raw materials is consistent with cost-minimization models that have been developed to understand foraging and horticultural economies (cf. Earle 1980). In terms of selection, therefore, cost minimization seems to have been an important factor that influenced the economic decision-making of prehistoric hunter-gatherers in south-central Florida.

It also is clear that the scale at which analysis is conducted affects the results of that research. This is evident in the comparison of organizational structure between chert-rich and chert-poor areas discussed above. At the interregional scale, access to raw materials was an important, if not a determining, factor that influenced the organizational structure of prehistoric lithic assemblages. Yet, at the intraregional scale, other factors emerged as important in influencing the specific strategies that were employed. The variability increases when individual sites are examined, the differences between Fort Center and other sites in the Kissimmee region are a prime example. The smaller the scale of reference, the greater the variability and the more difficult it is to arrive at generalizations. This does not mean that archaeologists should ignore variability in their quest for generalizations; it does mean that the study of both variability and patterning is important to achieve a better understanding of the selective processes that resulted in the adaptive behaviors that eventually are preserved, albeit incompletely, in the material record that is left for archaeologists to study.

Finally, the data presented here support previous interpretations of the importance of exchange in the development of Belle Glade social, political, and ideological systems, particularly as they are expressed at Fort Center (e.g., Austin 1987, 1993; Hale 1984, Sears 1982). The archaeological evidence suggests that exchange occurred on two levels -- subsistence goods and prestige goods. These two levels of exchange probably were closely related since access to prestige items was no doubt made possible through existing relations established as part of the process of exchange in subsistence goods. By providing access to exotic goods, exchange systems contributed to the development of the socially stratified and politically complex native societies encountered by the Spanish in the sixteenth century.

APPENDIX A
INVENTORIES OF ARTIFACT CLASSES AND RAW-MATERIAL CATEGORIES FOR ARCHAIC PERIOD ASSEMBLAGES

Appendix A Inventories of artifact classes and raw-material categories (quarry clusters and types) for Archaic period assemblages.

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
8HG18																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	4	5	1	7	11	0	1	1	0	0	0	0	0	4	3	0	0	0	0	0	37
Totals	0	4	5	1	9	11	0	2	1	0	0	0	0	0	4	3	0	0	0	0	0	40
8HG20																						
Bifaces	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Unifaces	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
Modified Flakes	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	9	2	1	0	4	1	0	0	0	0	2	2	0	0	0	0	0	21
Totals	0	0	1	0	13	3	1	0	4	1	0	0	0	0	4	2	0	0	0	0	0	29
8HG27																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
Totals	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
8HG34																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	7	0	1	4	13	0	0	0	0	0	2	0	0	0	0	0	0	27
Totals	0	0	0	0	7	0	1	4	13	0	0	0	0	0	3	0	0	0	0	0	0	28
8HG35																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	23	0	6	5	0	0	0	2	0	0	3	0	7	5	0	0	0	0	0	52
Totals	0	1	24	0	8	5	0	0	0	2	0	0	3	0	8	5	0	0	0	0	0	56
8HG51																						
Bifaces	0	0	1	0	0	0	0	0	0	0	0	0	4	0	2	1	0	0	0	0	0	8
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Utilized Flakes	0	0	0	0	1	0	2	0	0	1	0	0	4	0	2	2	0	0	0	0	0	12
Modified Flakes	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	4
Cores	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	1	2	28	7	33	8	6	4	7	2	0	0	391	0	57	19	0	0	0	0	0	565
Totals	1	3	29	7	36	8	8	4	7	3	0	0	401	0	62	22	0	0	0	0	0	591
8HG678																						
Bifaces	0	1	2	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	4	0	4	8	6	3	1	2	1	0	0	8	0	6	3	0	0	0	0	0	46
Totals	0	5	2	4	13	6	3	1	2	1	0	0	8	0	8	3	0	0	0	0	0	56

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
8HG767																						
Bifaces	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	5	1	12	0	0	0	0	2	0	0	14	0	2	4	0	0	0	0	0	40
Totals	0	0	5	4	13	0	0	0	0	2	0	0	14	0	2	7	0	0	0	0	0	47
8HR68																						
Bifaces	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
Unifaces	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	6	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	9
Modified Flakes	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Cores	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	3	0	125	25	0	15	19	6	0	0	12	0	23	27	0	0	0	0	0	255
Totals	0	0	3	0	139	30	1	15	20	6	0	0	12	0	23	28	0	0	0	0	0	277
8HR71																						
Bifaces	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Utilized Flakes	0	0	1	1	4	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	9
Modified Flakes	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	2	58	6	115	15	0	3	3	0	0	0	5	0	23	17	0	0	0	0	0	247
Totals	0	2	59	7	120	17	0	3	3	1	0	0	5	0	27	19	0	0	0	0	0	263
8HR92																						
Bifaces	1	0	1	0	4	0	0	1	0	0	0	0	1	0	3	2	0	0	0	0	0	13
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Utilized Flakes	0	0	0	0	5	4	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	12
Modified Flakes	0	0	0	0	1	1	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	5
Cores	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	6	60	8	195	39	1	10	26	10	0	0	24	0	65	32	0	1	0	0	0	477
Totals	1	6	61	8	208	44	1	13	26	10	0	0	25	0	72	34	0	1	0	0	0	510
Wells Site																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3
Unifaces	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Microliths	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Utilized Flakes	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Modified Flakes	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cores	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Debitage	0	0	74	9	260	0	0	3	6	2	0	0	0	0	134	13	0	0	0	0	0	501
Totals	0	0	78	9	270	0	0	3	6	2	0	0	0	0	137	13	0	0	0	0	0	518

APPENDIX B
INVENTORIES OF ARTIFACT CLASSES AND RAW-MATERIAL CATEGORIES FOR POST-ARCHAIC PERIOD ASSEMBLAGES

Appendix B. Inventories of artifact classes and raw-material categories (quarry clusters and types) for post-Archaic period assemblages.

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
8GL13																						
Bifaces	7	5	14	0	24	10	0	7	4	1	0	0	7	3	23	20	1	0	0	0	0	126
Unifaces	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Microliths	0	0	0	0	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	8
Utilized Flakes	1	1	1	0	22	3	1	1	1	0	0	0	2	5	3	1	1	0	0	0	0	43
Modified Flakes	0	0	0	0	6	0	0	1	0	0	0	0	0	3	0	2	0	0	0	0	0	12
Cores	1	0	0	0	2	1	0	0	0	0	0	0	0	20	0	0	3	0	0	0	0	27
Tested Cobbles	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0	0	0	0	0	0	0	57
Unmodified Cobbles	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	5
Hammerstones	0	0	0	0	1	0	0	0	0	0	0	0	0	6	0	1	0	0	0	0	0	8
Debitage	4	8	19	0	133	9	5	9	3	2	0	0	29	270	35	56	12	4	7	1	0	606
Totals	13	14	34	0	192	23	6	18	8	3	0	0	38	373	61	80	18	4	7	1	0	893
8HG18																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
Utilized Flakes	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	11	0	36	12	2	1	1	0	0	0	0	0	8	12	0	0	0	0	0	84
Totals	0	1	11	0	39	14	2	1	2	0	0	0	3	0	10	13	0	0	0	0	0	96

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
8HG20																						
Bifaces	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	5
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Microliths	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Utilized Flakes	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	12	0	55	12	1	1	2	0	0	0	0	0	10	10	0	0	0	0	0	104
Totals	0	2	12	0	61	14	1	1	2	0	0	0	1	0	11	14	0	0	0	0	0	119
8HG27																						
Bifaces	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	5
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
Utilized Flakes	0	2	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	6
Modified Flakes	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	6	0	15	3	1	4	0	0	0	0	0	0	21	11	0	0	0	0	0	62
Totals	0	3	6	0	17	5	2	4	0	0	0	0	0	0	25	17	0	0	0	0	0	79
8HG34																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Utilized Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	1	0	0	1	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	6
Totals	0	0	1	0	1	1	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	7
8HG665																						
Bifaces	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	1	0	5	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	12
Totals	1	0	2	0	6	1	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	18
8HG675																						
Bifaces	0	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Debitage	0	0	0	0	4	1	0	1	1	0	0	0	6	0	1	2	0	0	0	0	0	16
Totals	0	0	0	0	5	1	0	1	1	0	0	0	8	0	2	2	0	0	0	0	0	20
8HG678																						
Bifaces	0	1	0	0	5	1	0	1	0	0	0	0	2	0	1	1	0	0	0	0	0	12
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Utilized Flakes	0	0	0	0	1	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5
Modified Flakes	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	2	0	24	5	0	0	1	0	0	0	27	0	3	9	0	0	0	0	0	72
Totals	0	2	3	0	31	8	0	1	1	0	0	0	29	0	7	10	0	0	0	0	0	92
8HR44																						
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	1	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	5
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	7	0	0	3	0	0	0	0	152	0	0	6	0	0	0	0	0	168
Totals	0	0	1	0	8	0	0	3	0	0	0	0	161	0	0	6	0	0	0	0	0	179
8HR48																						
Bifaces	1	1	1	0	3	1	0	1	0	0	0	0	4	0	1	0	0	0	0	0	0	13

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3
Modified Flakes	0	0	0	0	3	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	6
Cores	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	8	3	1	0	24	10	1	10	4	0	0	0	74	0	23	17	0	0	0	0	0	175
Totals	9	4	2	0	32	11	1	11	4	0	0	0	81	0	25	19	0	0	0	0	0	199
8LL33, 36, 37																						
Bifaces	5	0	2	0	8	0	1	0	0	0	0	0	0	0	4	5	0	0	0	0	0	25
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Utilized Flakes	0	0	1	0	5	3	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	11
Modified Flakes	0	0	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6
Cores	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Hammerstones	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Debitage	0	0	4	0	27	3	2	12	0	1	0	0	0	0	4	12	1	10	0	1	0	77
Totals	5	0	7	0	50	6	6	16	0	1	0	0	0	0	10	17	1	11	0	1	0	131
8PI1753																						
Bifaces	0	0	1	0	4	1	1	2	1	2	0	0	0	0	6	3	0	0	0	0	0	21
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	12
Microlith Preforms	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	8
Utilized Flakes	0	0	1	0	5	1	1	4	0	1	2	0	0	0	5	1	0	0	1	0	0	22

Quarry Cluster	L	O	WR	B	HR					C	TCP		PR									
Type					HR	CHC	T3	T4	BB		T1	T2		COB	SC	UIDCH	QZ	DO	FB	UID	GL	Totals
Modified Flakes	0	0	0	0	3	0	1	2	0	0	2	0	0	0	1	1	0	0	0	0	0	10
Cores	0	0	0	0	0	1	0	1	0	0	8	0	0	0	1	0	0	0	0	0	0	11
Unmodified Rods	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	33
Hammerstones	0	0	1	0	1	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Debitage	0	0	4	0	79	18	20	63	2	14	63	25	0	0	14	14	0	0	10	0	0	326
Totals	0	0	7	0	92	24	23	73	3	18	##	25	0	0	27	19	0	0	11	0	0	450
8PO1685																						
Bifaces	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	1	0	3	1	0	0	0	0	0	0	1	0	2	1	0	0	0	0	1	10
Totals	0	0	2	0	4	1	0	0	0	0	0	0	2	0	2	2	0	0	0	0	1	14

APPENDIX C
INVENTORIES OF ARTIFACT CLASSES AND RAW-MATERIAL CATEGORIES BY INTRASITE FEATURE AT FORT CENTER (8GL13)

Appendix C. Inventories of artifact classes and raw-material categories (quarry clusters and types) by intrasite feature at Fort Center (8GL13).

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Mound A																			
Bifaces	4	4	2	0	10	1	0	0	0	0	1	3	4	11	0	0	0	0	40
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	7
Utilized Flakes	0	0	1	0	4	0	0	0	0	0	0	3	0	1	0	0	0	0	9
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0	0	0	5
Cores	1	0	0	0	0	0	0	0	0	0	0	18	0	0	2	0	0	0	21
Tested Cobbles	0	0	0	0	0	0	0	0	0	0	0	57	0	0	0	0	0	0	57
Unmodified Cobbles	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	5
Hammerstones	0	0	0	0	1	0	0	0	0	0	0	4	0	1	0	0	0	0	6
Debitage	3	3	3	0	57	4	3	1	0	1	0	258	11	32	7	3	7	1	394
Totals	8	7	6	0	75	5	3	1	0	1	1	355	15	46	10	3	7	1	544
Mound B																			
Bifaces	1*	1	3	0	5	4	0	0	2	0	1	0	7	3	0	0	0	0	27
Unifaces	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	1	0	0	5	1	0	1	0	0	0	0	2	0	1	0	0	0	11
Modified Flakes	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Cores	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	0	4
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	3	7	0	17	1	1	0	0	0	0	1	0	4	4	0	0	0	38
Totals	0	5	10	0	33	7	1	1	2	0	1	1	9	7	6	0	0	0	84

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Charnel Pond																			
Bifaces	0	0	2	0	2	2	0	0	1	0	0	0	4	0	0	0	0	0	11
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Debitage	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Totals	0	0	2	0	5	2	0	0	1	0	1	2	4	0	0	0	0	0	17
Midden A																			
Bifaces	1	0	2	0	3	1		1	0	1	1	0	2	3	0	0	0	0	15
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Utilized Flakes	0	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	6
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cores	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	1	1	5	0	27	1	1	7	1	1	3	5	16	14	1	0	0	0	84
Totals	2	1	7	0	36	3	2	8	1	2	4	6	18	17	1	0	0	0	108
Midden B																			
Bifaces	0	0	2	0	1	1	0	2	0	0	2	0	2	1	0	0	0	0	11
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Utilized Flakes	0	0	0	0	1	1	0	0	1	0	0	1	1	0	0	0	0	0	5
Modified Flakes	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	19	1	0	1	0	0	8	4	2	0	0	0	0	0	35
Totals	0	0	2	0	21	3	0	4	1	0	10	5	5	2	0	0	0	0	53
Great Circle																			
Bifaces	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	4
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	4	1	0	0	0	0	1	0	3	1	0	0	0	0	10
Totals	1	0	0	0	7	1	0	1	1	0	1	0	3	2	0	0	0	0	17
UF Mound																			
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Debitage	0	0	0	0	1	0	0	0	0	0	8	0	2	0	0	1	0	0	12
Totals	0	0	0	0	1	0	0	0	0	0	8	1	2	0	0	1	0	0	13
Mound 3																			
Bifaces	1*	0	1	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	5
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	3	0	5	1	0	0	1	0	8	2	0	1	0	0	0	0	21
Totals	0	0	4	0	6	1	0	0	1	0	11	2	1	1	0	0	0	0	28
Mound 11																			
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Mound 12																			
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Mound 13																			
Bifaces	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Miscellaneous																			
Bifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quarry Cluster	L	O	WR	B	HR					C	PR								
Type					HR	CHC	T3	T4	BB			COB	SC	UIDCH	QZ	DO	FB	UID	Totals
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	3
Totals	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	4
Unknown																			
Bifaces	0	0	2	0	2	1	0	2	0	0	0	0	2	1	1	0	0	0	11
Unifaces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microliths	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilized Flakes	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Modified Flakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hammerstones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debitage	0	1	0	0	3	0	0	0	1	0	0	0	0	3	0	0	0	0	8
Totals	0	1	2	0	8	1	0	2	1	0	0	0	2	4	1	0	0	0	22

APPENDIX D
RAW-MATERIAL IDENTIFICATIONS FOR HAFTED BIFACES

Appendix D. Raw-material identifications for hafted-bifaces.

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
8217105	8GL13	HR-T4	P	Marion
8217105	8GL13	WR	Y	Hardee
8217105	8GL13	HR	N	Hernando
8217105	8GL13	HR	Y	Pinellas
8217105	8GL13	QZ	N	UID Stemmed
97859	8GL13	SC	N	Hernando
98782-1	8GL13	SC	Y	Newnan
98782-2	8GL13	HR-CHC	N	Culbreath
98782-3	8GL13	HR-BB	N	Hardee
98782-4	8GL13	WR	Y	Bradford
98782-6	8GL13	SC	Y	Putnam
98782-7	8GL13	WR	N	UID Stemmed
98783	8GL13	HR	P	Culbreath?
98811-1	8GL13	SC	Y	Marion
A15190	8GL13	SC	Y	Diminutive FAS
A15232	8GL13	LS/LP	Y	Jackson
A15283	8GL13	HR-CHC	P	Diminutive FAS
A15303	8GL13	UID	N	Hernando
A15329	8GL13	HR	N	Hernando
A15379	8GL13	HR	N	Pinellas
A15421	8GL13	HR-CHC	Y	Ocala
A15433	8GL13	HR-T4	N	Hernando
A15632	8GL13	PR	N	Pinellas
A15656	8GL13	WR	N	UID Stemmed
A15661	8GL13	HR-T4	N	Diminutive FAS
A15670	8GL13	PR	N	Pinellas
A15674	8GL13	PR	N	Pinellas
A15763	8GL13	WR	N	Hernando
A15827	8GL13	SC	Y	Levy-like
A15828	8GL13	UID	N	Hernando
A15830	8GL13	HR-CHC	Y	Diminutive FAS
A15839	8GL13	SC	Y/TD	Newnan
A15863	8GL13	SC	Y	Marion
A15963	8GL13	WR	TD	Copena?
A15965	8GL13	SC	Y	Newnan
A15967	8GL13	WR	N	Marion
A15968	8GL13	HR-CHC	N	Hernando
A15990	8GL13	SC	Y	Hillsborough
A15992	8GL13	SC	Y	Marion

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
A15996	8GL13	HR	Y	Marion
A16022	8GL13	SC	N	Diminutive FAS
A16025	8GL13	HR-T4	N	Diminutive FAS
A16110	8GL13	HR	N	Hernando
A16112	8GL13	PR	N	Pinellas
A16127	8GL13	WR	P	Levy
A16163	8GL13	HR	N	Pinellas
A16230	8GL13	UID	N	Santa Fe
A16246	8GL13	LS/LP	N	Columbia
A16246	8GL13	LS/LP	N	Columbia
A16246	8GL13	UID	Y/TD	Columbia
A16262	8GL13	UID	TD	Tampa?
A16292	8GL13	HR	N	Columbia
A16313	8GL13	UID	TD	Jackson
A16324	8GL13	UID	N	Columbia
A16383	8GL13	LS/LP	N	Columbia
A16459	8GL13	UID	N	Columbia?
A16474	8GL13	SC	Y	Marion
A16490	8GL13	WR	N	Broward?
A16508	8GL13	LS/LP	N	Columbia
A16555	8GL13	SC	Y	Marion
A16557	8GL13	UID	N	Marianna?
A16569	8GL13	HR-CHC	N	Diminutive FAS
K-1	8HG18	SC	a	Alachua?
9344-111-1	8HG20	O	N	Citrus
94-111-1	8HG20	LS/LP	N	Citrus
9344-133-1	8HG27	HR-CHC	N	Hernando
94-158-5	8HG34	SC	Y	Marion
CP-01	8HG49	UID	P	Bolen, Subtype 3
CP-02	8HG49	SC	N	Newnan
CP-05	8HG49	WR	N	Levy-like
CP-07	8HG49	SC	P	Levy-like
CP-12	8HG49	HR-BB	N	Jackson
CP-15	8HG49	O	N	UID
CP-16	8HG49	WR	N	FAS
CP-17	8HG49	HR	N	Levy
CP-19	8HG49	HR-BB	N	Bolen, Subtype 1
CP-21	8HG49	SC	P	UID
CP-22	8HG49	UID	P	Putnam
CP-38	8HG49	SC	N	FAS

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
93-21-102	8HG51	PR	N	Newnan
93-21-103	8HG51	PR	N	Marion
93-41-98	8HG51	PR	N	Newnan
87-1-1	8HG665	HR	N	Hernando
C-1	8HG675	HR	N	Culbreath
94-03-1	8HG678	HR	N	Pinellas
94-10-2	8HG678	WR	Y	Newnan
94-58-1	8HG678	HR	N	Pinellas
94-72-2	8HG678	HR	Y	Newnan
94-91-1	8HG678	HR	N	Pinellas
94-91-2	8HG678	HR-CHC	N	Pinellas
B-01	8HG679	UID	N	Culbreath
B-03	8HG679	SC	N	Hillsborough
B-08	8HG679	SC	N	Levy
B-09	8HG679	UID	N	Jackson
B-10	8HG679	HR-BB	N	Bolen
B-11	8HG679	HR	N	Greenbriar
B-13	8HG679	WR	N	Westo?
B-30	8HG679	B	N	Putnam
BK-02	8HG679	UID	N	FAS
BK-03	8HG679	WR	N	Culbreath
BK-04	8HG679	SC	Y	Newnan
BK-05	8HG679	HR	N	Diminutive FAS
BK-06	8HG679	WR	N	UID Stemmed
BK-07	8HG679	C	N	Sumter?
BK-08	8HG679	UID	N	Putnam
BK-09	8HG679	HR-BB	N	UID Stemmed
BK-10	8HG679	UID	Y	Sumter
BK-12	8HG679	HR-BB	N	Bolen
BK-13	8HG679	SC	P	Westo?
BK-17	8HG679	HR	N	Diminutive FAS
BK-18	8HG679	UID	N	Diminutive FAS
BK-19	8HG679	HR	Y	Diminutive FAS
BP-01	8HG680	SC	Y	Newnan
BP-1-7	8HG680	HR-CHC	Y	Hernando
LJ-01	8HG681/764	SC	Y	Alachua
LJ-03	8HG681/764	LS/LP	N	FAS
LJ-04	8HG681/764	SC	Y	Putnam
LJ-05	8HG681/764	SC	Y	Newnan
LJ-06	8HG681/764	SC	Y	Newnan

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
LJ-08	8HG681/764	SC	N	Jackson
LJ-09	8HG681/764	B	P	Sumter?
LJ-10	8HG681/764	B	N	FAS
LJ-13	8HG681/764	HR	Y	Newnan
LJ-2-09	8HG681/764	B	N	Putnam
LJ-2-10	8HG681/764	B	N	Kirk?
LJ-2-11	8HG681/764	HR-BB	N	Bolen Beveled
LJ-2-14	8HG681/764	SC	Y	Newnan
LJ-3-02	8HG681/764	SC	Y	Kirk?
LJ-3-09	8HG681/764	WR	N	Bradford?
LJ-3-10	8HG681/764	SC	Y	Newnan
LJ-3-11	8HG681/764	OC	N	Sumter
LJ-3-12	8HG681/764	HR	N	Levy
LJ-3-29	8HG681/764	HR-BB	N	Bolen
LJ-3-30	8HG681/764	SC	P	Jackson?
LJ-3-40	8HG681/764	HR	N	FAS
LJ-3-41	8HG681/764	HR	N	Tampa
RR-01	8HG682	HR-T4	N	Marion
RR-02	8HG682	SC	Y	Newnan
RR-03	8HG682	SC	N	Putnam
RR-04	8HG682	UID	N	Pinellas
RR-05	8HG682	HR-CHC	N	Marion
SLP-01	8HG684	SC	N	Marion
SLP-02	8HG684	SC	Y	Marion
SLP-03	8HG684	SC	Y	Newnan
SLP-04	8HG684	HR	Y	Marion
SLP-05	8HG684	WR	N	Westo?
SLP-06	8HG684	UID	N	Hernando
SLP-08	8HG684	SC	Y	Marion
SLP-09	8HG684	HR-CHC	N	Marion
SLP-10	8HG684	HR-BB	N	Bradford?
SLP-12	8HG684	WR	Y	Levy
SLP-18	8HG684	UID	N	Levy
SLP-19	8HG684	B	N	Marion
SLP-21	8HG684	HR	N	Levy?
SLP-22	8HG684	HR	N	Levy
94-224-1	8HG688	HR	N	Diminutive FAS
SLAP-2	8HG697	HR-CHC	P	Putnam
M-01	8HG701	B	N	Newnan
M-03	8HG701	W	N	Hardee

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
M-07	8HG701	SC	N	Sumter
M-08	8HG701	HR	N	FAS?
M-09	8HG701	HR	N	Levy
M-10	8HG701	HR-CHC	N	Levy
M-11	8HG701	UID	N	Diminutive FAS
M-13	8HG701	WR	N	Marion
M-16	8HG701	SC	N	Diminutive FAS
M-17	8HG701	HR-BB	N	Greenbriar
SL-01	8HG701	HR-BB	N	Newnan
SL-02	8HG701	UID	N	Marion
BH-2	8HG724	UID	N	Putnam
BH-4	8HG724	WR	N	Newnan
RS-08	8HG739	SC	N	Marion
RS-06	8HG739	SC	Y	Marion
RS-15	8HG739	SC	Y	Marion
RS-05	8HG739	SC	Y	Newnan
35-127	8HG767	B	N	UID Stemmed
4-1	8HG767	B	Y	Newnan
92-1-27	8HR44	PR	N	Pinellas
91-39-2	8HR48	PR	N	Pinellas
92-154-4	8HR48	HR-CHC	N	Hernando
92-170-1	8HR48	WR	N	Duval
92-198-1	8HR48	PR	N	Pinellas
92-72-1	8HR48	LS/LP	P	Columbia
95-124-5	8HR68	UID	Y	Putnam
95-88-10	8HR71	HR-CHC	N	Hardee
90-1-2	8HR92	HR	Y	Levy
90-1-3	8HR92	WR	Y	FAS
95-108-1	8HR92	UID	N	Putnam
95-109-1	8HR92	HR	Y/TD	Putnam
95-39-88	8HR92	HR	Y	Putnam
95-64-1	8HR92	SC	Y	Putnam
88-8-41	8LL33,36,37	SC	N	Pinellas
89-7-10	8LL33,36,37	HR	N	Pinellas
90-13-1	8LL33,36,37	HR	N	Broward
90-13-7/16	8LL33,36,37	LS/LP	N	Broward
90-7-50-1/21	8LL33,36,37	SC	Y	Putnam
92-16-1/1	8LL33,36,37	WR	N	Ocala?
92-17-2	8LL33,36,37	HR	N	Taylor
92-24-1/3	8LL33,36,37	LS/LP	N	Sarasota

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
92-24-4/2	8LL33,36,37	LS/LP	N	Columbia
92-40-6/2	8LL33,36,37	SC	Y	Newnan
92-5-2/1	8LL33,36,37	LS/LP	Y	Duval
92-9-1	8LL33,36,37	HR	N	Broward
91-155-3	8PI1753	SC	Y	Pinellas
91-187-2	8PI1753	HR	N	Beaver Lake
94-16-2	8PI1753	HR-T4	N	Ocala
94-205-24	8PI1753	HR	TD	Pinellas
94-223-3	8PI1753	UID	Y	Levy-like
94-232-1	8PI1753	SC	P	Bradford
94-28-8	8PI1753	HR-CHC	N	Newnan-like
94-34-1	8PI1753	UID	N	Jackson
94-34-2	8PI1753	HR-T4	N	Bradford
94-52-13	8PI1753	SC	Y	Pinellas
41-1	8PO4698	SC	Y	Newnan
LL-01	Lake Livingston	UID	N	Marion
LL-02	Lake Livingston	WR	Y	Newnan
LL-18	Lake Livingston	HR	N	Bolen
LL-19	Lake Livingston	WR	N	Sumter
LL-20	Lake Livingston	SC	Y	Diminutive FAS
LL-23	Lake Livingston	HR	Y	Marion
LL-24	Lake Livingston	O	N	Levy
LL-26	Lake Livingston	C	N	FAS
LL-27	Lake Livingston	SC	Y	UID Stemmed
LL-30	Lake Livingston	WR	N	Levy
LL-31	Lake Livingston	UID	N	Diminutive FAS
LL-33	Lake Livingston	SC	Y	UID Stemmed
LL-34	Lake Livingston	SC	Y	Levy?
LL-35	Lake Livingston	C	N	Marion
LL-36	Lake Livingston	WR	N	Duval?
LL-38	Lake Livingston	WR	P	UID Stemmed
LL-39	Lake Livingston	WR	N	Diminutive FAS
LL-40	Lake Livingston	WR	N	Diminutive FAS
LL-44	Lake Livingston	SC	Y	Diminutive FAS
LL-45	Lake Livingston	WR	N	Diminutive FAS
LL-46	Lake Livingston	SC	Y	Diminutive FAS
LL-48	Lake Livingston	SC	N	Levy
LL-49	Lake Livingston	HR-BB	N	Diminutive FAS
LL-50	Lake Livingston	O	N	Putnam
LL-51	Lake Livingston	WR	Y	UID

ID#	Site Number	Quarry Cluster	Thermal Alteration	Type
LL-52	Lake Livingston	HR-CHC	N	FAS
LL-53	Lake Livingston	PR	N	Diminutive FAS
LL-54	Lake Livingston	HR?	Y	UID Stemmed
LL-55	Lake Livingston	WR	N	Hardee?
LL-56	Lake Livingston	HR	N	Putnam
LL-57	Lake Livingston	WR	N	Diminutive FAS
LL-58	Lake Livingston	HR-CHC	N	Marion
LL-59	Lake Livingston	HR-T4	P	Newnan
LL-60	Lake Livingston	SC	Y	Newnan
LL-61	Lake Livingston	SC	Y	Newnan
LL-62	Lake Livingston	WR	Y	Marion
LL-63	Lake Livingston	SC	Y	Newnan
LL-64	Lake Livingston	O	Y	Marion
LL-65	Lake Livingston	B	N	Marion
LL-66	Lake Livingston	B	N	Marion
LL-67	Lake Livingston	UID	Y	Newnan
LL-68	Lake Livingston	SC	Y	UID Stemmed
SR -1	Skipper Road	HR	N	Hernando
HW-01	State Road 70	HR-BB	N	Levy
HW-02	State Road 70	WR	N	Westo?
HW-03	State Road 70	B	Y	Levy
HW-04	State Road 70	SC	N	Westo?
HW-05	State Road 70	B	N	Marion
HW-06	State Road 70	B	N	Marion
HW-07	State Road 70	SC	Y	Diminutive FAS
HW-08	State Road 70	HR-BB	N	Marion
HW-09	State Road 70	HR-BB	N	Marion
HW-11	State Road 70	UID	N	Hernando
HW-14	State Road 70	WR	N	Westo?
HW-19	State Road 70	B	N	Levy
HW-28	State Road 70	HR-BB	N	Bolen, Subtype 1
HW-29	State Road 70	WR	N	FAS
HW-31	State Road 70	SC	Y	Newnan
HW-32	State Road 70	WR	N	Newnan

APPENDIX E
DIMENSIONAL DATA FOR COMPLETE HAFTED BIFACES

Appendix E. Dimensional data for complete hafted bifaces.

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL:W	MBW:W
8217105	8GL13	Hardee	65.30	33.20	11.45	248.23	54.75	19.05	1.65	0.57
8217105	8GL13	Hernando	56.45	21.95	6.30	78.06	52.60	12.10	2.40	0.55
8217105	8GL13	Marion	75.95	43.45	11.05	364.65	59.65	32.05	1.37	0.74
8217105	8GL13	Pinellas	28.65	15.30	6.00	26.30	28.65	11.65	NA	0.76
8217105	8GL13	UID Stemmed	49.90	32.65	11.50	187.36	36.55	15.90	1.12	0.49
97859	8GL13	Hernando	55.55	21.80	5.50	66.60	50.95	14.85	2.34	0.68
98782-2	8GL13	Culbreath	59.25	37.55	9.65	214.70	47.95	23.85	1.28	0.64
98782-3	8GL13	Hardee	61.05	33.25	8.65	175.59	47.65	20.45	1.43	0.62
98782-4	8GL13	Bradford	62.40	41.25	13.70	352.64	45.10	30.80	1.09	0.75
98782-6	8GL13	Putnam	61.80	32.10	11.00	218.22	45.10	24.10	1.40	0.75
98782-7	8GL13	UID Stemmed	54.15	22.55	11.20	136.76	45.15	15.00	2.00	0.67
98783	8GL13	Culbreath?	49.20	28.85	7.30	103.62	35.10	19.00	1.22	0.66
98811-1	8GL13	Marion	90.09	50.75	6.75	308.61	73.95	38.05	1.46	0.75
A15190	8GL13	Diminutive FAS	26.25	22.80	5.00	29.93	14.40	15.65	0.63	0.69
A15283	8GL13	Diminutive FAS	26.75	22.10	6.95	41.09	17.95	15.45	0.81	0.70
A15303	8GL13	Hernando	55.35	23.50	5.90	76.74	46.50	14.75	1.98	0.63
A15379	8GL13	Pinellas	33.50	11.10	4.65	17.29	33.50	8.45	NA	0.76
A15632	8GL13	Pinellas	26.65	17.00	8.10	36.70	26.65	10.00	NA	0.59
A15661	8GL13	Diminutive FAS	35.10	19.35	7.40	50.26	23.75	13.90	1.23	0.72
A15674	8GL13	Pinellas	26.00	12.60	4.70	15.40	26.00	10.00	NA	0.79
A15827	8GL13	Levy-like	51.05	33.25	7.85	133.25	40.35	22.95	1.21	0.69
A15830	8GL13	Diminutive FAS	40.25	36.50	10.35	152.05	27.95	28.50	0.77	0.78
A15863	8GL13	Marion	36.45	28.25	7.30	75.17	22.85	18.75	0.81	0.66
A15963	8GL13	Copena?	44.85	18.75	5.85	49.19	31.80	13.00	1.70	0.69

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL:W	MBW:W
A15967	8GL13	Marion	45.95	37.10	7.45	127.00	31.95	27.10	0.86	0.73
A15990	8GL13	Hillsborough	56.05	36.55	5.90	120.87	48.35	20.60	1.32	0.56
A15992	8GL13	Marion	40.50	32.15	7.65	99.61	28.65	21.65	0.89	0.67
A16022	8GL13	Diminutive FAS	36.60	26.50	8.40	81.47	26.75	18.40	1.01	0.69
A16025	8GL13	Diminutive FAS	31.40	24.50	6.90	53.08	24.70	17.15	1.01	0.70
A16112	8GL13	Pinellas	34.15	14.85	4.90	24.85	34.15	10.60	NA	0.71
A16127	8GL13	Levy	53.75	31.70	12.65	215.54	40.95	21.25	1.29	0.67
A16230	8GL13	Santa Fe	74.00	22.45	6.90	114.63	58.10	15.80	2.59	0.70
A16246	8GL13	Columbia	60.95	26.60	8.50	137.81	43.90	22.00	1.65	0.83
A16246	8GL13	Columbia	67.85	27.85	8.00	151.17	53.60	22.80	1.92	0.82
A16383	8GL13	Columbia	55.75	26.00	8.75	126.83	45.00	20.00	1.73	0.77
A16459	8GL13	Columbia?	72.90	32.50	9.25	219.16	63.70	24.90	1.96	0.77
A16474	8GL13	Marion	61.35	37.15	9.40	214.24	46.15	27.25	1.24	0.73
A16490	8GL13	Broward?	69.30	32.95	9.40	214.64	54.35	29.85	1.65	0.91
A16555	8GL13	Marion	45.40	32.70	6.70	99.47	31.40	23.70	0.96	0.72
A16557	8GL13	Marianna?	43.80	24.35	6.75	71.99	NM	13.95	NA	0.57
A16569	8GL13	Diminutive FAS	32.10	26.90	7.25	62.60	22.50	15.95	0.84	0.59
K-1	8HG18	Alachua?	50.00	35.00	6.00	105.00	41.45	27.20	1.18	0.78
K-2	8HG18	Diminutive FAS	30.00	22.00	6.00	39.60	22.60	13.95	1.03	0.63
K-3	8HG18	Diminutive FAS	32.00	26.00	5.00	41.60	22.75	16.90	0.88	0.65
94-158-5	8HG34	Marion	34.90	27.20	8.00	75.94	25.05	21.10	0.92	0.78
K-5	8HG35	Putnam	44.00	34.00	6.00	89.76	24.05	23.15	0.71	0.68
CP-02	8HG49	Newnan	33.45	28.25	5.67	53.55	23.70	18.60	0.84	0.66
CP-05	8HG49	Levy-like	38.50	27.95	6.73	72.46	31.75	14.55	1.14	0.52
CP-12	8HG49	Jackson	33.25	19.05	7.07	44.76	26.05	13.85	1.37	0.73

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL:W	MBW:W
CP-15	8HG49	UID	31.20	21.10	7.62	50.14	20.90	15.20	0.99	0.72
CP-21	8HG49	UID	19.00	18.10	5.32	18.28	13.20	8.90	0.73	0.49
CP-22	8HG49	Putnam	28.45	29.65	7.43	62.70	18.95	17.70	0.64	0.60
93-21-102	8HG51	Newnan	42.50	33.50	8.35	118.88	31.00	21.15	0.93	0.63
93-21-103	8HG51	Marion	40.45	29.25	8.20	97.02	28.85	19.00	0.99	0.65
93-41-98	8HG51	Newnan	40.45	35.95	8.95	130.15	31.95	21.00	0.89	0.58
87-1-1	8HG665	Hernando	38.60	20.00	6.10	47.09	32.85	13.30	1.64	0.67
92-203-1	8HG675	UID	18.40	16.00	5.45	16.04	14.60	7.10	0.91	0.44
94-58-1	8HG678	Pinellas	25.70	15.80	6.70	27.21	25.70	9.70	1.63	NA
94-91-1	8HG678	Pinellas	21.15	15.90	5.85	19.67	21.15	10.05	1.33	NA
94-91-2	8HG678	Pinellas	20.30	15.75	4.35	13.91	20.30	9.05	1.29	NA
B-01	8HG679	Culbreath	42.43	32.20	9.40	128.43	33.65	16.70	1.05	0.52
B-03	8HG679	Hillsborough	38.55	29.50	4.95	56.29	34.80	18.75	1.18	0.64
B-08	8HG679	Levy	37.20	29.85	9.60	106.60	26.50	12.75	0.89	0.43
B-09	8HG679	Jackson	33.25	19.30	7.15	45.88	24.60	13.20	1.27	0.68
B-10	8HG679	Bolen	33.75	23.30	NM	NA	24.10	13.10	1.03	0.56
B-11	8HG679	Greenbriar	37.00	21.55	NM	NA	27.45	15.05	1.27	0.70
B-13	8HG679	Westo?	45.15	23.85	NM	NA	30.90	21.10	1.30	0.88
B-30	8HG679	Putnam	47.90	27.00	NM	NA	36.75	18.90	1.36	0.70
SLP-01	8HG684	Marion	42.85	32.95	7.70	108.72	28.05	22.25	0.85	0.68
SLP-02	8HG684	Marion	40.95	30.70	7.00	88.00	28.00	19.45	0.91	0.63
SLP-04	8HG684	Marion	44.90	30.15	5.95	80.55	34.35	22.40	1.14	0.74
SLP-05	8HG684	Westo?	34.20	26.15	11.35	101.51	24.25	16.90	0.93	0.65
SLP-10	8HG684	Bradford?	36.25	30.60	8.50	94.29	29.85	20.25	0.98	0.66
SLP-19	8HG684	Marion	45.95	35.50	8.95	145.99	33.70	24.70	0.95	0.70

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL/W	MBW/W
94-224-1	8HG688	Dim FAS	31.30	23.20	5.55	40.30	23.75	13.60	1.02	0.59
M-01	8HG701	Newnan	65.10	39.80	9.50	246.14	42.85	27.95	1.08	0.70
M-03	8HG701	Hardee	36.55	22.55	7.35	60.58	29.80	13.60	1.32	0.60
M-07	8HG701	Sumter	67.80	31.90	8.85	191.41	54.95	27.55	1.72	0.86
M-10	8HG701	Levy	57.60	44.15	8.35	212.34	37.35	25.65	0.85	0.58
M-13	8HG701	Marion	59.95	45.35	7.95	216.14	51.50	28.95	1.14	0.64
M-16	8HG701	Diminutive FAS	28.25	24.70	8.45	58.96	17.70	15.45	0.72	0.63
M-17	8HG701	Greenbriar	32.55	23.65	6.70	51.58	21.75	15.50	0.92	0.66
SL-02	8HG701	Marion	49.55	47.40	10.65	250.13	35.20	29.55	0.74	0.62
TL-2	8HG721	Sumter	42.40	27.35	13.80	160.03	27.50	20.70	1.01	0.76
RS-03	8HG739	FAS	39.10	24.60	8.30	79.83	26.85	18.90	1.09	0.77
RS-04	8HG739	Marion	35.90	26.95	5.50	53.21	27.00	16.60	1.00	0.62
RS-15	8HG739	Marion	33.35	37.25	5.35	66.46	20.90	19.55	0.56	0.52
RS-01	8HG739	Culbreath	66.40	38.35	8.55	217.72	54.45	30.55	1.42	0.80
RS-10	8HG739	Marion	51.00	30.35	5.00	77.39	41.85	25.05	1.38	0.83
RS-07	8HG739	Marion	64.45	37.45	9.30	224.47	52.80	29.00	1.41	0.77
RS-05	8HG739	Newnan	44.05	33.10	7.60	110.81	37.15	25.95	1.12	0.78
WP-1	8HG743	Newnan	68.65	47.25	5.25	170.29	59.90	36.90	1.27	0.78
35-127	8HG767	UID Stemmed	56.30	28.60	13.15	211.74	36.10	22.25	1.26	0.78
4-1	8HG767	Newnan	57.00	37.35	9.60	204.38	40.25	19.80	1.08	0.53
92-1-27	8HR44	Pinellas	22.00	12.85	4.40	12.44	22.00	7.70	1.71	0.60
92-170-1	8HR48	Duval	67.35	24.55	10.70	176.92	49.30	16.95	2.01	0.69
92-198-1	8HR48	Pinellas	24.75	14.80	6.25	22.89	24.75	8.55	1.67	0.58
92-72-1	8HR48	Columbia	73.35	26.80	9.50	186.75	59.00	19.70	2.20	0.74
92-72-1	8HR48	Columbia	73.35	26.80	9.50	186.75	59.00	19.70	2.20	0.74

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL:W	MBW:W
95-124-5	8HR68	Putnam	42.35	27.85	9.45	111.46	27.50	19.30	0.99	0.69
95-88-	8HR71	Hardee	44.00	25.15	8.65	95.72	30.50	14.05	1.21	0.56
95-39-88	8HR92	Putnam	40.40	25.55	9.15	94.45	26.90	18.95	1.05	0.74
88-8-41	8LL33/37	Pinellas	33.25	16.55	6.30	34.67	33.25	11.20	2.01	0.68
89-7-10	8LL33/37	Pinellas	23.70	16.60	7.50	29.51	23.70	6.35	1.43	0.38
90-13-1	8LL33/37	Broward	60.60	30.25	8.40	153.98	48.45	24.30	1.60	0.80
90-13-7/16	8LL33/37	Broward	78.00	32.05	8.95	223.74	67.10	28.90	2.09	0.90
90-7-50-1/21	8LL33/37	Putnam	69.20	36.15	8.25	206.38	57.65	25.15	1.59	0.70
92-16-1/1	8LL33/37	Ocala?	75.35	30.35	7.80	178.38	63.60	25.80	2.10	0.85
92-17-2	8LL33/37	Taylor	45.55	26.00	7.65	90.60	35.90	20.15	1.38	0.78
92-24-1/3	8LL33/37	Sarasota	86.25	30.40	7.75	203.21	73.40	25.70	2.41	0.85
92-24-4/2	8LL33/37	Columbia	65.60	25.60	7.35	123.43	54.55	18.90	2.13	0.74
92-40-6/2	8LL33/37	Newnan	49.45	29.95	7.40	109.60	41.15	20.10	1.37	0.67
92-5-2/1	8LL33/37	Duval	51.15	17.10	8.90	77.85	41.65	12.65	2.44	0.74
92-9-1	8LL33/37	Broward	64.30	28.90	7.00	130.08	52.00	21.65	1.80	0.75
91-155-3	8PI1753	Pinellas	22.75	10.80	2.95	7.25	22.75	8.45	2.11	0.78
91-187-2	8PI1753	Beaver Lake	59.40	18.45	6.70	73.43	59.40	17.40	3.22	0.94
94-223-3	8PI1753	Levy-like	51.35	25.65	10.30	135.66	37.85	19.10	1.48	0.74
94-232-1	8PI1753	Bradford	48.90	29.65	10.00	144.99	36.35	22.35	1.23	0.75
94-28-8	8PI1753	Newnan-like	56.00	34.75	9.05	176.11	44.50	24.85	1.28	0.72
94-34-1	8PI1753	Jackson	55.25	22.00	7.85	95.42	44.10	17.85	2.00	0.81
94-34-2	8PI1753	Bradford	48.95	29.30	9.85	141.27	34.35	22.55	1.17	0.77
94-52-13	8PI1753	Pinellas	20.25	17.50	0.91	3.22	20.25	10.30	1.16	0.59
LL-01	Lake Livingston	Marion	51.65	30.02	8.85	137.22	38.40	20.70	1.28	0.69
LL-18	Lake Livingston	Bolen	43.65	23.15	7.45	75.28	34.75	16.55	1.50	0.71

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL:W	MBW:W
LL-19	Lake Livingston	Sumter	70.00	35.15	12.35	303.87	54.15	33.30	1.54	0.95
LL-20	Lake Livingston	Diminutive FAS	43.90	23.50	7.85	80.98	34.65	15.20	1.47	0.65
LL-23	Lake Livingston	Marion	33.25	35.20	7.45	87.19	26.90	25.50	0.76	0.72
LL-24	Lake Livingston	Levy	58.40	46.75	9.90	270.29	48.00	24.05	1.03	0.51
LL-26	Lake Livingston	FAS	55.80	32.20	9.45	169.79	45.80	27.00	1.42	0.84
LL-27	Lake Livingston	UID Stemmed	30.00	23.70	8.05	57.24	23.60	17.95	1.00	0.76
LL-30	Lake Livingston	Levy	55.90	37.55	10.00	209.90	45.10	23.40	1.20	0.62
LL-31	Lake Livingston	Diminutive FAS	27.00	20.55	8.35	46.33	17.00	13.10	0.83	0.64
LL-34	Lake Livingston	Levy?	41.75	28.85	8.00	96.36	30.95	21.05	1.07	0.73
LL-35	Lake Livingston	Marion	39.20	33.10	10.50	136.24	27.15	24.45	0.82	0.74
LL-36	Lake Livingston	Duval?	45.50	21.85	10.55	104.89	37.75	13.60	1.73	0.62
LL-38	Lake Livingston	UID Stemmed	35.05	21.70	8.80	66.93	29.80	16.60	1.37	0.76
LL-40	Lake Livingston	Diminutive FAS	54.70	24.20	8.80	116.49	43.75	17.50	1.81	0.72
LL-45	Lake Livingston	Diminutive FAS	30.00	24.30	7.85	57.23	22.00	16.60	0.91	0.68
LL-46	Lake Livingston	Diminutive FAS	22.05	21.40	6.10	28.78	15.25	11.00	0.71	0.51
LL-48	Lake Livingston	Levy	52.50	34.75	8.20	149.60	39.55	22.00	1.14	0.63
LL-49	Lake Livingston	Diminutive FAS	51.90	27.45	11.50	163.84	43.50	23.00	1.58	0.84
LL-50	Lake Livingston	Putnam	47.15	31.40	7.85	116.22	30.85	19.95	0.98	0.64
LL-51	Lake Livingston	UID	47.50	33.00	10.75	168.51	39.70	29.25	1.20	0.89
LL-52	Lake Livingston	FAS	57.40	38.85	9.30	207.39	38.95	34.95	1.00	0.90
LL-53	Lake Livingston	Diminutive FAS	47.00	33.35	10.10	158.31	36.55	25.00	1.10	0.75
LL-55	Lake Livingston	Hardee?	59.95	29.60	8.75	155.27	46.45	22.25	1.57	0.75
LL-56	Lake Livingston	Putnam	41.20	25.50	8.55	89.83	27.75	16.65	1.09	0.65
LL-57	Lake Livingston	Diminutive FAS	54.75	32.85	12.50	224.82	41.30	31.15	1.26	0.95
LL-58	Lake Livingston	Marion	47.25	33.85	7.30	116.76	32.05	26.65	0.95	0.79

ID#	Site Number	Type	Length	Width	Thickness	Size Index	Blade Length	Mid-blade Width	BL.W	MBW.W
LL-59	Lake Livingston	Newnan	90.25	43.05	8.70	338.02	72.25	33.05	1.68	0.77
LL-61	Lake Livingston	Newnan	47.40	39.00	8.55	158.06	31.25	26.90	0.80	0.69
LL-62	Lake Livingston	Marion	42.90	39.60	6.90	117.22	33.30	30.15	0.84	0.76
LL-63	Lake Livingston	Newnan/Marion	50.80	34.00	6.55	113.13	46.30	24.75	1.36	0.73
LL-64	Lake Livingston	Marion	41.00	27.95	8.10	92.82	24.90	15.45	0.89	0.55
LL-65	Lake Livingston	Marion	49.60	40.60	7.60	153.05	32.75	22.10	0.81	0.54
LL-66	Lake Livingston	Marion	56.35	35.95	9.00	182.32	36.00	14.95	1.00	0.42
LL-67	Lake Livingston	Newnan/Marion	47.45	29.75	6.55	92.46	35.70	19.70	1.20	0.66
K-6	Sandy Point	Diminutive FAS	25.00	19.00	6.00	28.50	17.35	13.15	0.91	0.69
HW-01	State Road 70	Levy	46.15	35.20	7.00	113.71	35.65	25.95	1.01	0.74
HW-02	State Road 70	Westo?	34.95	24.25	6.23	52.83	25.00	16.25	1.03	0.67
HW-03	State Road 70	Levy or Putnam	48.55	32.88	5.62	89.66	38.40	22.95	1.17	0.70
HW-04	State Road 70	Westo?	43.10	32.25	9.68	134.60	29.10	26.45	0.90	0.82
HW-05	State Road 70	Marion	61.50	42.55	7.55	197.57	44.80	27.05	1.05	0.64
HW-06	State Road 70	Marion	82.70	49.10	8.15	330.94	65.80	32.80	1.34	0.67
HW-08	State Road 70	Marion	54.85	38.90	8.62	183.85	37.05	27.00	0.95	0.69
HW-09	State Road 70	Marion	56.65	36.90	7.40	154.69	42.20	30.50	1.14	0.83
HW-11	State Road 70	Hernando	50.85	22.55	3.77	43.19	46.90	17.40	2.08	0.77
HW-14	State Road 70	Westo?	33.50	24.45	6.37	52.15	24.60	19.30	1.01	0.79
HW-19	State Road 70	Levy	55.75	31.75	6.67	118.00	43.55	16.90	1.37	0.53
HW-28	State Road 70	Bolen	22.80	16.45	4.47	16.75	14.90	8.65	0.91	0.53
HW-A13507	State Road 70	Diminutive FAS	28.45	25.68	5.32	38.84	21.15	14.15	0.82	0.55

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BIOGRAPHICAL SKETCH

Robert James Austin was born in Berea, Ohio, on May 31, 1949. His family moved to Florida in 1952 and he attended elementary and secondary schools in St. Petersburg, Florida. In 1967 he entered St. Petersburg Junior College and graduated with an Associate Arts degree in 1970. In January of 1971 he entered the University of South Florida and graduated in 1973 with a Bachelor of Arts degree in English. In 1978 he reentered the University of South Florida to pursue a degree in anthropology. He received a Bachelor of Arts degree in anthropology in 1979 and a Master of Arts degree in applied anthropology (public archaeology track) in 1983. He entered the graduate program in Anthropology at the University of Florida in 1992 to pursue the degree of Doctor of Philosophy. From 1979 to 1985 he worked as an archaeologist for numerous private consulting firms and government agencies. Since 1985 he has been employed by Janus Research (formerly Piper Archaeological Research, Inc.), a cultural resource management firm in St. Petersburg, Florida, where he is currently Executive Vice President. He is a member of the Phi Kappa Phi national honor society as well as many professional organizations. He married the former Karen Marie Davis in 1987 and they presently reside in Riverview, Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Jerald T. Milanich, Chair
Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Steven A. Brandt
Associate Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Douglas S. Jones
Professor of Geology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

William F. Keegan
Associate Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

William H. Marquardt
Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Sam B. Upchurch
Courtesy Professor of Geology
University of South Florida

This dissertation was submitted to the Graduate Faculty of the Department of Anthropology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Dean, Graduate School

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